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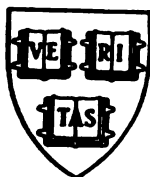
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SCIENCE ABSTRACTS.

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SUBJECT INDEX.

SECTION A.—PHYSICS.

To facilitate reference to any desired subject, the Index is divided into the following sections arranged alphabetically. If any of these are absent this may be taken as an indication that no Abstracts dealing with those particular subjects have been included in this volume.

Where phenomena such as the Hall-effect, Thomson-effect, Zeeman-effect, etc., are mentioned in an Abstract but not in the Title, the reference will be found in the Name Index.

The numbers refer to Abstracts; if the letter B follows a number the Abstract will be found in Section B under that number.

- In General Physics* :—Apparatus and Instruments (physical, excluding electrical, descriptive); Astronomy; Diffusion; Dynamics; Elasticity; Gravity; Measurements and Use of Instruments; Meteorology, &c.; Miscellaneous; Molecular Physics, Matter and Ether; Pressures (high and low); Surface Tension; Terrestrial Physics; Theories; Viscosity.
- In Light* :—Absorption; Dispersion; Interference; Measurements and Use of Instruments; Miscellaneous; Phosphorescence and Fluorescence; Photography; Photometry; Polarisation; Radio-activity; Rays and Radiation; Reflection of Light; Refraction of Light; Spectra; Vision; Zeeman-Effect and Radiation in a Magnetic Field.
- In Heat* :—Absorption; Conductivity; Critical Points and Constants; Dilatation; Freezing, Melting-, and Boiling-Points; Gases and Vapours; Measurements and Use of Instruments; Miscellaneous; Specific Heat and Latent Heat; Temperature; Temperatures (high and low); Thermodynamics; Thermometry, Pyrometry, and Calorimetry; Vapour Pressure.
- In Sound* :—All Abstracts referring to this subject have been indexed under *Sound*.
- In Electricity and Magnetism* :—Absorption; Alternate-Current Research; Apparatus and Instruments (descriptive); Capacity (electrostatic); Conductivity and Resistivity; Dielectrics; Discharge in Gases and in Vacuo; Electromagnetic Theory; Inductance (self and mutual); Magnetism; Measurements and Use of Instruments; Electro-Physiology and Radiography; Miscellaneous; Oscillations and Waves; Polarisation (electric waves); Polarisation (electrolytic); Static and Atmospheric Electricity; Terrestrial Magnetism and Electricity; Thermo-Electricity and Thermo-Magnetism
- In Chemical Physics* :—Absorption; Alloys; Batteries (primary); Batteries (secondary); Chemical Equilibrium; Dissociation and Ionisation; Electric Furnace Processes; Electrolysis; Electrolytic Analysis; Metallography and Properties of Metals; Miscellaneous; Osmosis; Solution and Solubility.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1914.

GENERAL PHYSICS.

1. *Demonstration of Pendulum Law.* **A. Pizzarello.** (N. Cimento, 5. Ser. 6. pp. 407–411, June, 1913.)—Several devices are described for altering the restoring force in the case of a pendulum, with the object of showing that the period of oscillation always varies as the square root of the restoring force. S. G. S.

2. *Units of Force.* **O. Lehmann.** (Zeitschr. Instrumentenk, 88. pp. 279–280, Sept., 1913.)—With units the metre, the kilogramme, and the second, the unit of force becomes a decimegadyne. Call this a *Cop* (from Copernicus). Then $1 \text{ Cop} \times 1 \text{ metre} = 1 \text{ Joule}$; activity = 1 watt; and other expressions are convenient. [See Abstract No. 546 (1918).] A. D.

3. *A Formula in Interpolation.* **L. H. Adams.** (Washington Acad. Sci., Journ. 8. pp. 469–474, Nov. 19, 1913.)—The author points out the limitations of the use of a formula of the type $y = a + bx + cx^2 + dx^3 + \dots$ for expressing experimental results. He suggests formulæ of the type $y = ax + b(1 - e^{-cx})$ or $y = ax + b \log(\cosh cx)$ as useful in certain cases, and illustrates by numerical examples the great accuracy that can sometimes be obtained by their use. A. R.

4. *A Physical Interpretation of the Bessel Function of Zero Order.* **J. Hollingworth.** (Phil. Mag. 26. pp. 427–440, Sept., 1913.)—The author points out that mathematical physics can be considered from two points of view. In the first we consider the differential equation arrived at from first principles and solve it by purely formal mathematical methods. The solution is reinterpreted into physical ideas and applied to the problem in question. In the second way we proceed as follows. We regard the complex problem as a generalisation from the simple principles involved. These principles can be expressed mathematically, and, consequently, by generalising from these we may be able to build up the same solution as before. A solution of the equation $\partial^2 y / \partial x^2 + 1/x \cdot \partial y / \partial x + y = 0$, is obtained by both methods, and so their relative values can be judged. A. R.

5. *The Increase in Projectile Velocity in Front of the Gun Muzzle.* **M. Ôkôchi.** (Mathematico-Physical Soc., Tôkyô, Proc. 7. pp. 104-114, June, 1918.)—The author commences by pointing out the importance of projectile velocity in calculating ballistical effects. The muzzle velocity is generally determined by means of the Boulenge chronograph for artillery purposes, and takes the form of measuring the interval of time between the breaking of two current circuits, one being a thin wire stretched across the muzzle and the other an installation 50 to 100 m. away. From the average velocity so found, the muzzle velocity may be calculated by utilising a law of air-resistance. Many authorities consider that the method is not sufficiently exact, since the powder gases are active some metres beyond the muzzle, the latter observation having been first made by Crehore and Squier by means of their "polarising photo-chronograph." This result has since been obtained by Indra, who used the Boulenge chronograph, and Radacović with the condenser chronograph. A complete investigation resulted in establishing that the projectile velocity was greatest at the muzzle, decreasing up to 75 cm. away, and then increasing once more up to 165 cm. from the muzzle, when the velocity attained a second but smaller max. velocity. Investigations by W. Wolff with the 8-mm. rifle, using different charges, could establish no increase in velocity after leaving the muzzle, the latter velocity being the maximum from which a continuous decrease was recorded. The results of other investigators, together with those described, being so contradictory, the present author has made comprehensive experiments with the Japanese 6.5-mm. infantry rifle M/98. For this investigation a species of drum-chronograph was employed with a number of charged Leyden jars instead of induction spirals. The jars were so arranged that at the instant when the projectile passed any appointed position the corresponding jar emitted a spark which could be seen on a rapidly rotating drum. The author gives considerable details of his apparatus illustrated by a diagram, and discusses the possible sources of error. Tables, diagrams, and a mathematical discussion of the results obtained then follow. The author could not establish waves produced by the projectile shortly after leaving the muzzle, as it still lies in a rapidly moving medium, for the powder gases are travelling with almost double the velocity of the projectile, so that its velocity increases until the air-resistance begins to exert its influence. It is extremely probable that there is no minimum velocity between the muzzle and the point of max. velocity, and, further, that a continuous velocity-decrease from the mouth onwards only takes place in cases where the charge very quickly burns out and the muzzle pressure is extraordinarily low. The max. velocity of the projectile from the Japanese rifle M/98 was found at a distance of about 1.5 m. from the muzzle, and is about 0.8 per cent. greater than the muzzle velocity which the shot again possesses at about 5 m. from the muzzle.

H. H. HO.

6. *Theory of Gravity.* **S. B. McLaren.** (Phil. Mag. 26. pp. 686-678, Oct., 1918.)—A mathematical and quasi-speculative essay on gravity based on (1) B. Riemann's view that the *ether* is a fluid and *matter* a region where the ether is continually destroyed, and (2) the modern principle of relativity.

E. H. B.

7. *Gravitation from the Standpoint of Relativity.* **G. Nordström.** (Ann. d. Physik, 42. 3. pp. 538-554, Oct. 16, 1918.)—A highly analytical treatment of the theory of gravitation on the relativity principle. The inertia and gravity
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masses of a spherical electron are calculated, and the dependence of mass and length on gravitational potential are discussed. [See Abstracts Nos. 354 and 1250 (1918).] E. H. B.

8. *Relativity*. R. A. Wetzel. (Science, 38. pp. 466-474, Oct. 3, 1913.)—A semi-popular *résumé* of the theory of relativity illustrated by a relativity model showing two systems each capable of relative motion and each bearing two clocks which may be set at will. [See Abstract No. 2277 (1905).] E. H. B.

9. *Stationary and Moving Systems*. K. Tamaki. (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 285-252, May, 1913.)—A mathematical treatment by vector analysis obtaining symmetrical expressions of the relations between the physical quantities in the two systems. E. H. B.

10. *Motion of a Viscous Fluid*. Rayleigh. (Phil. Mag. 26. pp. 776-786, Oct., 1913.)—A mathematical discussion of the stability of certain fluid motions based on the works of Helmholtz (Collected Works, 1869) and Korteweg (Phil. Mag., 1883). E. H. B.

11. *Flow of Viscous Fluids through Orifices*. G. F. Davidson. (Roy. Soc., Proc. Ser. A. 80. pp. 91-99, Aug. 19, 1913.)—Describes experiments on drowned orifices using heavy engine oil as a fluid. The effects of the boundaries are examined. A baffle-plate one diam. from the orifice on the downstream side produces no effect. Thus the results obtained are considered true within 1 % for one infinite fluid flowing into another through an orifice of the kind used. When water is used as a fluid the coefficient of discharge is about 1 or 2 per cent. less for drowned than for free discharge. Curiously, friction can increase the flow by preventing contraction of the issuing jet. The problem is discussed by the method of dimensions, and it is shown that the fundamental assumption that stress is proportional to strain in a viscous fluid is not true. Special experiments to determine the variation of viscosity with varying rates of distortion are described; the viscosity varies from 18.7 to 9.4 as the rate of distortion varies from 20 to 280. (Rate of distortion in a tube is defined as $8V/3R$.) The variation of viscosity with varying rate of distortion precludes any application of the laws of similar flow because the rate of distortion varies from point to point and the corresponding changes in ν will alter the form of flow. H. S. R.

12. *Turbulence Viscosity of Water*. W. Sorkau. (Phys. Zeitschr. 14. pp. 759-766, Aug. 15, and pp. 828-831, Sept. 1, 1913.)—Discusses the formulæ for Hagen's turbulence viscosity as dependent upon temperature and pressure, and defends his own formula as against that of Schaefer and Frankenberg. The supposed "turbulence II" between Hagen's turbulence and the frictionless ("solid") flow is doubtful. The pressure at which the Poiseuille flow is pure stable quickly falls with a rising temperature. It is therefore very doubtful where the Poiseuille viscosity is really measured when examining a liquid in an Ostwald viscosity tube close up to the boiling-point. E. E. F.

13. *Inertia of Energy*. P. Langevin. (Journ. de Physique, 8. Ser. 5. pp. 558-591, July, 1913.)—Mass may be defined as: (1) an inertia coefficient; (2) a capacity for impulse or quantity of movement; (3) a capacity for kinetic
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energy. It is a postulate of Rational Dynamics that these definitions are congruous and that mass is unaltered by mechanical, physical, and chemical changes. The constancy of mass is a consequence (1) of assuming inertia to be fundamental; (2) of assuming the equality of action and reaction; (3) of assuming the conservation of energy. Inertia can no longer be regarded as fundamental, as it is expressible, at least in part, electromagnetically. The three definitions are then congruous only when the velocity is small relatively to that of light; and even this *initial mass*, as it may be called, varies with every gain or loss of energy. Rational Dynamics must therefore be regarded as merely a first approximation, which, however, is sufficient for most purposes; and the conservation of mass as an approximate consequence of the more fundamental concept of the conservation of energy. The author traces the development of the electromagnetic expression of inertia from its origin in Maxwell's equations establishing the convection current, the creation by a moving charged body of an accompanying magnetic field; J. J. Thomson's analytic development; the experimental verification by Rowland and his pupils; down to Poincaré's proof that just as conservation of energy necessitated the localisation of energy in the electromagnetic field, so conservation of quantity of movement necessitated its similar localisation. Calling W_0 the initial energy of a body, W the energy absorbed, in virtue of its electric charge, in setting it in motion, W_e , W_m , the energy of its electrostatic and electromagnetic fields, respectively, then $W = W_e + W_m - W_0$. Since W becomes infinite for a body moving with the speed of light, the latter is necessarily a superior limit to the speed of any portion of matter, a result following as a consequence of the fact that the electromagnetic nature of light is itself a consequence of Maxwell's law of electric displacement.

When mass is defined as an inertia coefficient it can only give an electromagnetic mass, a function only of the velocity, provided that the electric and magnetic fields are wholly determined in terms of the velocity at any instant, and this will be the case only for *quasi-stationary* movements in which the accelerations are too small to give rise to sensible radiation. The principles of conservation then hold, and coefficients of inertia can be defined as quotients of the force by the acceleration which it produces. But there are two cases giving rise to different values: *longitudinal mass* when the force and velocity are in the same direction, so that the acceleration is a change in magnitude only; *transverse mass* when the force and velocity are at right angles, so that the acceleration is a change in direction only. For a total impulse G , and a velocity v , the value of the former is dG/dv , and that of the latter is G/v , which Poincaré has called the Maupertuisian mass [defined by (2)]. The latter is the simpler, and is, moreover, the mass concerned in the deviation of cathode rays, β -particles, etc., by electric forces perpendicular to their directions; it will therefore be taken as *the mass* simply. The expression of this mass as a function of the velocity is complicated if charge be supposed carried by undeformed sphere, but the assumption of the Lorentz-Fitzgerald contraction leads to the simple formula $m = m_0 / \sqrt{1 - \beta^2}$, where m_0 is the initial mass, its value at rest or low speeds, and β is the ratio of the speed to the speed of light. Moreover, it is in accordance with the Lorentz transformations which constitute the foundation of the *Principle of Relativity*, and as Einstein has shown, the contraction is merely one of the aspects of the modifications in the ideas of time and space involved in this principle. Further, as Poincaré has pointed out, non-electromagnetic forces are requisite to prevent dissipation of the charge of an electron, if regarded as a charge e , of surface density σ , on a sphere of radius

a. The simplest force would be a pressure $p = 2\pi\sigma^2/K_0 = e^2/8\pi K_0 a^4$, where K_0 is the specific inductive capacity of the ether, and supposing such a pressure everywhere exerted by the ether, the spherical electron would be deformed into an oblate spheroid having the polar semiaxis $a\sqrt{1-\beta^2}$. The potential energy at rest, E_0 , is then shown to be related to the initial mass, m_0 , by the simple expression $m_0 = E_0/c^2$, where c is the velocity of light. The consideration of a simple case then leads to the conclusion that a moving system will conserve its identity for an observer moving with it only if the ether pressure corresponding to the Poincaré pressure on the electron remain constant, and that the total impulse, in the direction of motion, will be $E_0 v/c^2$, where v is the velocity of the system; and it is shown to follow from this that every variation in the internal energy of a system through emission or absorption of radiation must be accompanied by a corresponding diminution or increase in the inertia of the system. Mass must therefore vary with temperature and chemical changes. The amount of such change is found, however, to be too small to be verified by direct measurement. But it is noteworthy that the observed deviations of atomic mass from Prout's law are satisfactorily accounted for by these variations. If the velocity of light in space be taken as a fundamental unit, then the mass of a body will become identified with its total energy, and its initial mass with its internal energy.

G. W. DE T.

14. Structure of the Atom. J. J. Thomson. (Phil. Mag. 26. pp. 792-799, Oct., 1918. Paper read before the British Association at Birmingham.)—The author here attempts to construct an atom in which the transformation of radiant into kinetic energy would take place in accordance with Planck's law. The intra-atomic forces need not necessarily obey the observed electrostatic laws, which represent an averaged effect, and the author makes the initial assumptions that the forces acting upon a corpuscle in the atom are: (1) A radial repulsive force, varying inversely as the cube of the distance from the centre, diffused throughout the whole of the atom. (2) A radial attractive force, varying inversely as the square of the distance from the centre, *confined to a limited number of radial tubes in the atom.* It is of interest to note that very much the effect of the former would result from something in the structure of the atom which should make the moment of momentum of a corpuscle about an axis in the atom a universal constant. A corpuscle within a tube of attraction might be removed to infinity, in the tube, or by leaving it sideways and then coming under the uncontrolled action of the repulsion, and, by the conservation of energy, the work done against the attractive force must be the same in either case. The following results then follow mathematically, an integration constant being suitably chosen: (1) The kinetic energy with which a corpuscle is expelled from the atom by the impact of light of frequency n is proportional to nh , where h is Planck's constant, the well-known law of Photo-electricity. (2) Radiant energy of frequency n will be absorbed only in multiples of nh ; for unless the corpuscle receive sufficient energy to displace it from the tube, it will be left vibrating with frequency n which will be dissipated by radiation, so that the light will be scattered without absorption. (8) The potential energy of a corpuscle entering the atom from outside will be converted into radiation of frequency n by multiples of hn ; e.g. a cathode particle striking an atom will penetrate until stopped by the repulsive force, when it will be repelled and ejected. While within the atom it will be accelerated and will therefore emit radiation, constituting Röntgen rays, the frequency of

sponding to existing atoms, the number of electrons in the atom is assumed equal to the number indicating the position of the corresponding element in the periodic series of increasing atomic weight, except only where deviations from the periodic law are observed. The symbol $N(n_1, n_2, \dots)$ will represent a plane system of N rings with nucleus Ne , and with n_1, n_2, \dots electrons in each ring, beginning with the inner; $a_1, \dots, \omega_1, \dots$ will represent the radii and frequencies; and $W[N(n_1, n_2, \dots)]$ will represent the energy emitted during formation. Then for a neutral H-atom 1(1), $a = 0.55 \times 10^{-8}$, $\omega = 6.2 \times 10^{15}$, $W = 2 \times 10^{-11}$, values of the orders to be expected; e.g. $W/e = 0.048$, or 13 volts, while the ionising potential of a H-atom is found by J. J. Thomson to be 11 volts [Abstract No. 1870 (1918)]. Since $W[1(2)] > W[1(1)]$ a H-atom should be capable of acquiring a negative charge, as agrees with experiments on positive rays, but not of acquiring a double negative charge, since $W[1(8)] = 0.54.10^{-11}$ only. For the permanent state of a positively-charged He-atom, 2(1), $a = \frac{1}{2}a_0$, $\omega = 4\omega_0$, $W = 4W_0$, where a_0, ω_0, W_0 are the values for 1(1). For considerable distances the system 2(1) will act on a free electron as a simple nucleus of charge e , so that stationary states in which the most lightly bound electron moves as in H-atom may be assumed, but concentric rings would be too near for stability, so two confluent rings or two rings of equal radii in parallel planes will be the configuration suggested. The addition of a further electron would lead to a smaller value of W , indicating that a negative charge cannot be acquired, which agrees with experiment [Abstract No. 1479 (1910)]. For neutral Li and Be atoms the author arrives at the configurations 3(2, 1) and 4(2, 2), passing through the formation stages 3(1), 3(2), and 4(1), 4(2), 4(2, 1) respectively. Negatively-charged atoms 3(2, 2) and 4(2, 3) may be formed from these, and in the latter case there will still remain a definite, though very small, affinity for free electrons.

Now suppose that in two coplanar rings the electrons in one act on those in the other as though the charge were uniformly distributed round the ring, still, with this approximation, conserving the constant angular momentum of the electrons and the stability for displacements perpendicular to the plane. Let the inner ring now be pulled slowly to one side of the plane by applied forces parallel to the axis. Then the repulsion of the inner ring will cause the outer one to move to the opposite side of the plane. During the process one ring will increase and the other diminish in radius. At a certain distance apart they will be in equilibrium, but the only stable case is that of two rings with equal numbers of electrons, when the configuration may be stable for equal radii, the electrons in one ring being opposite the intervals between the electrons in the other, for this corresponds to the smallest total energy. Otherwise the rings will either return to their original positions or interchange them. With uniform distribution of the charge round the rings there could be no confluence, but, taking account of the discrete distribution, this is found possible when the numbers of electrons are equal and the rotations in the same direction. They will then unite, provided the final configuration be stable, in which case the electrons in one ring will be equally interspersed between those in the other. The constancy of angular momentum is then obviously satisfied. If the charge of the nucleus be very great, the rings of electrons first bound, if few in number, will be very close together, giving very unstable configuration, and facilitating gradual interchange of electrons, but otherwise there will be confluence only between rings with equal numbers of electrons, so the numbers on inner rings should be only 2, 4, 8, ..., a conclusion strongly supported by the fact that the chemical properties of the elements of low atomic mass vary with a period of 8. Further,

the number of electrons in the outer ring will be odd or even according as the number of the electrons in the atom is odd or even, which bears a suggestive relation to the fact that the valency of such an element is odd or even according as its number in the periodic series is odd or even.

G. W. DE T.

16. Determination of Gaseous Molecules by Maxwell's Theory. P. Kotournitzky. (Russian Physico-Chemical Soc., Journ. 44. 8. pp. 151-156, 1912.)—The author gives a theoretical discussion of the question based upon Maxwell's theory, in the course of which he obtains a table from which the co-ordinates F , X , Y were determined for intervals 0-1, 1-2, 2-3, and also for intervals between interval (0-2) divided into five equal parts. In the following table are shown the nearest dimensions for the number of molecules (Σn_u) and their kinetic energy ($\Sigma mu^2/2u^3$), in round percentages of the total number of molecules (N) and full amount of kinetic energy of the gas ($mu^2/2N$), neglecting fractions of percentages :—

	$u/w = s = 0.0-0.4$	$0.4-0.8$	$0.8-1.2$	$1.2-1.6$	$1.6-2$	$2-3$	$0-3$
Number of molecules	4	22	82	25	12	5	100
Kinetic energy	0	6	22	82	25	15	100

Comparing intervals 0.8-1.2 and 1.2-1.6 we notice in the last the kinetic energy (82 : 22) is 10 % greater than in the first, although the number of molecules in the last case is 7 % smaller than in the first ; and this is explained by their greater velocity. The total of these three intervals, $22 + 82 + 25 = 79$, already reaches 79 %, the rest accounting for only 21 % of the full number of molecules and full kinetic energy of the gas.

I. P.

17. Molecular Currents and Temperature Discontinuity. H. Bolza, M. Born, and T. v. Kármán. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 221-235, 1918.)—A supplement to the kinetic theory of rarefied gases dealing with: (1) Flow of a gas through a solid grating ; (2) pure molecular flow ; (3) comparison with Kundsen's formula.

E. H. B.

18. Kinetic Theory of Surface Tension. E. Madelung. (Phys. Zeitschr. 14. pp. 729-731, Aug. 15, 1913.)—The law of Eötvös (1886) is an empirical relation between the surface tension α of a liquid, the molecular volume V_0 , and the temperature T of the form $\alpha V_0^{2/3} = K(T' - T)$, where K is a constant of the mean value 2.12 and T' is a temperature not far from the critical temperature. The author endeavours to derive this law from molecular theory. Assuming the equipartition of energy, the molecules at the surface and in the interior must have the same energy, and as the forces at the surface are feeble the amplitude of oscillation must be greater. The "oscillation volume" is therefore compressed when a portion of liquid is brought from the surface to the interior, as when two cm.³ of surface layer are brought together with their flat faces. The calculation requires a knowledge of the number of molecules per cm.³. This is made possible by assuming that in the liquid state the distribution of molecules is also by space lattices. The author gives on this basis a theoretical deduction of the law. The constant is of the same order of magnitude as the empirical constant.

E. E. F.

19. Kinetic Theory of Surface Tension. M. Born and R. Courant. (Phys. Zeitschr. 14. pp. 731-740, Aug. 15, 1913.)—The authors apply Debye's

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method of evaluating specific heats to the problem of the relation between temperature and surface tension. One is justified in the case of liquids, even more than in the case of solids, in regarding the isotropic body as a continuum. It is assumed that the thermal oscillations of a liquid take place under the influence of cohesive forces, such as are evidenced by surface tension at the surface, and by compressibility in the interior. The treatment is purely phenomenological, and the laws of hydrodynamics and capillarity are used in a merely formal manner. The molecular conception only enters where, out of the infinite number of vibrations of the continuum, the first 8 N are identified with molecular vibrations. When the distribution of vibrations is thus found, the free energy of the liquid is calculated from Planck's resonator formulæ, as in solids. The law of Eötvös then becomes a special case of a more general formula.

E. E. F.

20. On Radiation Equilibrium and Atmospheric Radiation. R. Emden. (K. Bayer. Akad. München, Ber. p, 55, 1918. Meteorolog. Zeitschr. 80. pp. 452-454, Sept., 1918.)—The isothermal conditions in the stratosphere show that the air is in radiation equilibrium there, each particle losing by radiation as much heat as it gains through the same agency. Gold, in his work on the subject, made the assumption that radiation equilibrium implied that the streams of energy passing up and down through a given layer were equal to one another. This is true if the spectra of the two streams are identical; but it would not be true if, for example, the downward and upward streams consisted respectively of a short-wave and a long-wave radiation. Radiation equilibrium would obtain if the former stream were in excess of the latter, provided the absorption were less in the downward than the upward stream. If the earth radiates as a "black" body, and the atmosphere as a "grey" body throughout the spectrum, it can be computed that when radiation equilibrium is attained, the atmosphere is isothermal and its temperature is 254° A. As, however, the atmosphere does not radiate as a "grey" body throughout the spectrum, it cannot be isothermal under radiation equilibrium, but the difference between up and down radiation is then constant at each point. Assuming as a first approximation that the atmosphere may be divided into two parts, the stratosphere, in which there is no appreciable water-vapour, and the troposphere, where the mean amount of water-vapour is approximately known by observation, and assuming further that in the two parts the atmosphere acts as two unequally "grey" bodies, a table of temperatures under radiation equilibrium is obtained, which shows a minimum temperature of 216° A. at $11\frac{1}{2}$ km., gradually rising to 254° A. at the extreme limit of the atmosphere. Below $11\frac{1}{2}$ km. temperature rises, at first very slowly, but at 8 km., where the temperature is about 236° A., the vertical temperature gradient becomes equal to the adiabatic. Below 8 km. the gradient continues rapidly to increase, and at the surface (temperature 289° A.), it is 2.35° C. per 100 m. Thus in the state of radiation equilibrium the atmosphere in the troposphere above 8 km. would be in stable equilibrium, while below 8 km. the equilibrium would be unstable and convection would ensue, thus disturbing the radiation equilibrium and conveying heat up to the stratosphere.

R. C.

21. Computation of the Radiation Equilibrium of the Atmosphere. K. Schwarzschild. (Meteorolog. Zeitschr. 80. pp. 454-456, Sept., 1918.)—In Emden's paper [see preceding Abstract] the computation of atmospheric temperatures in the case of radiation equilibrium is carried out for the special

case in which the coefficients of absorption in the two parts of the atmosphere considered are certain definite functions of the air mass per unit volume. The author shows how the computation may still be performed in the more general case, when the coefficients of absorption are any functions of the mass per unit volume. R. C.

22. *Curious Formation of Cirrus Cloud.* P. Flajolet. (Comptes Rendus, 157. pp. 558-560, Oct. 6, 1918.)—Birkeland has recently suggested that a possible mode of production of cirrus may be looked for in the effects produced by secondary electric currents in the earth and the lower part of the atmosphere surrounding it. The primary currents which induce the secondary currents are those circulating in the higher layers of the atmosphere, and they are due to helio-kathodic rays deflected towards the earth by its magnetism.

On Sept. 20, 1918, about 20 parallel bands of cirrus were observed at the observatory of S. Genis-Laval, in the evening. The system of bands crossed the zenith, where it was about 80° wide, and its direction was nearly at right angles to the magnetic meridian. After about 20 minutes the bands began to disappear at their western end, but until the time of final disappearance the mean direction remained unaltered. The curves of horizontal and vertical components of magnetic force showed no unusual features at the time, but the magnetic declination was slightly disturbed; a maximum having occurred 25 mins. before the bands were first noticed, and a minimum being noted 80 mins. after the maximum. The amplitude of the disturbance was $1\frac{1}{2}'$.

R. C.

23. *Atmospheric Transmission of Earth Radiation.* A. Ångström. (Astrophys. Journ. 88. pp. 198-200, Sept., 1918.)—In view of the discordances between the estimates of various observers for the coefficient of transmission of earth radiation by the atmosphere (Very's estimate is 40 %; Abbot and Fowle's 10 %), an examination is made of the results of observations of atmospheric radiation at different heights above sea-level. The conclusion is that the transmission for clear sky is seldom greater than 25 % or less than 5 %.

C. P. B.

24. *Undagraph, Wave-counter.* O. Klotz. (Nature, 92. pp. 97-98, Sept. 25, 1918.)—In connection with the Dominion Astronomical Observatory, Canada, a wave-counter, or undagraph, has been installed at Chebucto, near Halifax, Nova Scotia, on a granite cliff 110 ft. high facing the Atlantic. Recent investigations in seismology have tended to show that microseisms, or earth tremors, are largely due to the impact of the breaking seas during storms; these show specially from autumn to spring, during the winter stormy season. Their period ranges from 4-7 secs., while their amplitude appears to vary with the gradient of the "low" on the water along the coast. Results are to be published as soon as available.

C. P. B.

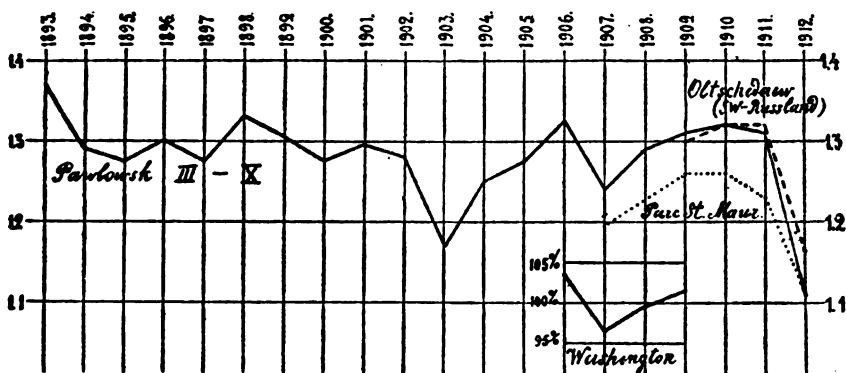
25. *Greatest Magnitudes of the Intensity of Solar Radiation Observed at Pavlovsk from 1892. Enfeblement of the Radiation in the Second Half of 1912.* C. I. Savinov. (Acad. Sci. St. Pétersbourg, Bull. 12. pp. 707-720, Sept. 15, 1918.)—Actinometric observations have been taken at Pavlovsk regularly since Sept., 1892. Since that time Ångström's differential pyrheliometer and Chwolson's actinometer have been used. The author examines the results which have been obtained, and affords comparisons between the instruments used at Pavlovsk and those of the Smithsonian Institution, and Potsdam. A

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chart showing the monthly maxima of the intensity of solar radiation from the year 1892 is given in the original, according to the observations at Pavlovsk, and in the table below are exhibited the exact figures for each of the twelve months in order.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.
93	0.93	(1.08)	1.39	(1.43)	1.41	1.40	1.84	1.35	1.37	1.26	1.01	—
94	0.95	(1.12)	1.32	(1.38)	1.37	(1.30)	(1.30)	(1.25)	(1.24)	1.22	1.12	0.88
95	—	1.19	1.36	(1.37)	1.32	(1.30)	(1.17)	1.33	1.32	(1.03)	(0.93)	0.91
96	1.09	1.26	1.38	1.34	1.40	1.25	1.30	—	1.26	1.20	0.88	0.85
97	—	1.20	1.27	(1.42)	(1.32)	(1.34)	1.27	1.18	1.34	(1.05)	0.92	0.90
98	1.13	1.11	(1.38)	1.43	(1.35)	(1.33)	—	1.27	—	1.30	1.00	0.76
99	1.07	(1.30)	1.38	1.40	1.35	(1.40)	(1.32)	(1.19)	1.20	(1.21)	1.03	—
1900	(1.01)	1.21	1.35	1.32	1.34	1.32	1.23	1.25	(1.27)	(1.12)	(0.88)	0.77
01	0.80	(1.18)	1.35	1.39	1.44	1.25	(1.29)	(1.30)	1.23	(1.10)	0.95	—
02	—	(1.22)	(1.33)	1.42	1.37	1.29	1.26	(1.25)	(1.21)	(1.17)	0.93	—
03	0.64	(1.00)	1.16	(1.18)	1.24	(1.16)	1.21	1.17	1.19	(1.04)	0.95	0.60
04	0.78	0.94	1.34	1.33	1.24	1.24	(1.24)	1.20	1.24	1.19	—	0.69
05	0.88	1.10	1.32	1.29	1.37	1.23	—	1.34	(1.29)	1.13	—	(0.78)
06	1.07	(1.02)	1.36	1.36	1.36	1.30	1.30	1.26	1.35	1.30	1.13	(0.78)
07	1.02	1.17	1.38	1.34	1.28	1.26	1.16	1.15	1.20	1.14	0.84	0.66
08	(0.73)	(0.92)	1.24	1.32	1.34	1.37	1.34	1.25	1.23	1.22	1.10	—
09	(1.05)	1.09	1.24	(1.27)	1.38	1.37	1.35	(1.29)	1.33	1.27	1.02	—
10	(0.92)	1.15	1.34	1.38	1.31	1.34	1.30	1.35	1.38	1.27	1.06	—
11	0.94	1.23	1.35	1.40	1.33	1.37	1.34	1.30	(1.14)	1.26	—	(0.88)
12	1.05	1.23	1.30	1.35	1.39	1.33	1.02	1.00	0.70	0.80	(0.52)	(0.39)
13	0.76	1.01	1.21	1.16	—	—	—	—	—	—	—	—

Anomalous radiation is noticeable during the second half of the year 1912, more so than in 1903–1904 and in 1907–1908. It is not possible to attribute the anomalies to the weather, but they are rather more likely to be due to the eruptions of volcanoes. The dust projected would cause a sudden



declension in the intensity of radiation as observed on the earth, and there would be a much more gradual return to a normal state of things as the dust was slowly dispersed or deposited. The evidence obtained elsewhere is in favour of this view. The eruptions of Mont Pelée, and that in Alaska in 1912, not to speak of Krakatoa, were known to have a widespread effect. The

chart here reproduced compares the records for a few years of Pavlovsk, Nizni Ottschedaew, Paris, and Washington, which favour the assumptions of the writer.

E. O. W.

26. *Water and the Magmatic Gases.* A. L. Day and E. S. Shepherd. (Washington Acad. Sci. Journ. 8, pp. 457-468, Nov. 4, 1918.)—From observations made on the Kilauea crater W. L. Green in 1887 and A. Brun in 1911 concluded that water of magmatic origin is not found among the gases exhaled by active volcanoes. Neither of the observers studied the gases at the point where they issued from the crater. The present authors descended into the Kilauea and inserted a tube directly into one of the cracks near the lava lake from which burning gas was rising; by a pipe-line, 8 m. in length, the tube was connected with a train of collecting tubes and a piston pump. As soon as the pump was worked, water was seen to condense in the glass tubes; this water served as a wash bottle. The analyses, partly made at Hawaii and mostly in Washington, proved the presence of many gases, SO_2 , CO_2 , CO , H , N , which, at the high temperature, above 1000°C ., could not be in equilibrium. The actual percentage of water could not be determined; the condensed water contained oxides of Na , K , Ca , Fe , Al , further SO_2 and traces of NH_3 , Cl , F , TiO_2 . But there was no chlorine in the gas, nor was any argon or other rare gas found; this absence of argon is striking. The very small percentage of chlorine found agrees with the analyses of lava which had for years been exposed to the smoke cloud from the crater.

H. B.

27. *Absorption of the Sun's Energy by Lakes.* E. A. Birge. (Science, 88, pp. 702-704, Nov. 14, 1918.)—Observations on the intensity of the solar radiation at different depths below the surface have been made on several of the inland lakes of Wisconsin. The amount of energy at 1 m. below the surface varies from 2 to 20 % of that at the surface. As a rule the depth at which 1 % of the surface energy is found lies between 8 and 4 m., while practically no heat radiation ever penetrates below 6 m. The percentage of the surface energy found at any given depth does not show much proportionality to the transparency of the water as measured by Secchi's disc.

J. S. Di.

28. *Theory of the Mediterranean Tides.* R. v. Sterneck. (Akad. Wiss. Wien, Ber. 122. 2a, pp. 299-364, Feb., 1918.)—Originally the author commenced to study whether the tidal oscillations of the Mediterranean had the character of free or forced vibrations, and found that while those of the Mediterranean were forced those of the Adriatic were free. The discussion of these oscillations does not necessitate, however, the question of the relationship between the separate basins of the Mediterranean, but of the water exchange between them during the course of a tidal period, since to each tidal oscillation there generally occur parallel movements of the surface which cause considerable quantities of water to flow between the different basins through the connecting straits. The latter circumstance has received too little notice hitherto, and the author admits his own neglect of it in a previous publication on tidal phenomena in the western Mediterranean [see Abstract No. 861 (1918)]. The present paper is an attempt to deal with the whole of the available data so as to produce a comprehensive solution. A sketch of the equilibrium theory of tides is first undertaken with mathematical treatment, followed by a discussion of tidal phenomena in the Mediterranean and in the Black Sea. The results of the latter discussion are then compared with

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those given on the equilibrium theory, and a formula for calculating the oscillation period is established. The case of the Black Sea then receives special treatment, as here the conditions are the least complex since the sea is practically a separate entity. Following this comes a discussion of the oscillation period of the western basin of the Mediterranean together with an estimation of its water balance. The important problem of the currents through the Gibraltar Straits then receives exhaustive treatment, and this section of the paper concludes with an elaborate theoretical examination of the oscillation period of the western basin. The eastern basin next receives attention, the particular case of the Adriatic Sea, including its special oscillation period and water balance, being carefully investigated, and an amended theory proposed. The conclusions arrived at are summarised by the author as follows :—(1) In the western basin the oscillations take place about an eccentric Spanish-Algerian nodal line determined by the author in the previous paper referred to ; in the eastern basin and in the Black Sea the nodal line must, in the absence of positive data, be placed provisionally in the middle between the east and west boundaries. The Adriatic Sea, however, undergoes complicated oscillations, since high water makes the circuit once in 12·8 hours, and this is the case also of the Sicilian Sea which is the central portion between the two larger basins. (2) The equilibrium theory, according to G. H. Darwin, is still applicable to seas of dimensions similar to those of the Mediterranean basins. According to the latter the average port time of the basin must always amount to 8 o'clock in the West and 9 o'clock in the East ; in reality, however, retardation of these times should be expected on account of the inertia of the water, a circumstance actually occurring in the eastern basin and the Black Sea. In the western basin, on the contrary, small accelerations are found which necessitate special explanation. In the Adriatic Sea a direct reversal of these port times is observed. The amplitude dimensions tolerably agree in the western and eastern basins, and also in the Black Sea, with those calculated on the equilibrium theory, but in the Adriatic the observed amplitude is nine times the calculated and in addition has a contrary phase. (3) Although G. H. Darwin regarded the Gibraltar currents as unimportant and the Mediterranean as an enclosed sea for tidal purposes in which the separate parts are fairly independent of each other, yet the observations of C. S. Nares on the Gibraltar currents and on the water movements through the channel between Sicily and Tunis, the Straits of Messina, and from the Adriatic through the Straits of Otranto, show that as exact a water balance as possible is maintained. (4) The water entry into the western basin produces a surface elevation of 13·8 cm., while a corresponding depression takes place during the water exit. This movement combined with the tidal oscillation causes an appreciable shifting of the nodal line towards the west, and affords the only explanation of its eccentric position. (5) The variations of the port times of the western basin are explained by the author as due to the influence of high and low water in the neighbouring Atlantic on the Gibraltar currents. (6) In the Adriatic the periodic entry and exit of 16·5 cubic kilometres of water through the Straits of Otranto produces a rise and fall of the surface of 11·2 cm., and this movement, combined with the tidal oscillation, accounts for the eccentric character of the nodal lines. (7) The special oscillation periods in the western and eastern Mediterranean and in the Black Sea cause the conclusion to be drawn that the oscillations are forced, while the corresponding data for the Adriatic point to the oscillations being free.

H. H. Ho,

29. *The Distribution of Ocean Temperatures along the West Coast of North America deduced from Ekman's Theory of the Upwelling of Cold Water from the Adjacent Ocean Depths.* G. F. McEwen. (Internat. Review of Hydrobiology and Hydrography, pp. 248-284, 1912.)—It has long been known that the temperature of the sea water contiguous to the west coast of N. America is abnormally cold in comparison with the ordinary sea temperature for the same latitudes. Many theories have been put forward in the past to explain this phenomenon. The chief are reviewed in this paper and found to be unsatisfactory. It has been customary when dealing with ocean currents to adopt Zoeppritz's theory on the relation between these and the prevailing winds. This theory took no account of the earth's rotation. The chief deductions were (1) that the current produced was in the same direction as the prevailing wind at all depths, and (2) that a period amounting to several hundreds of years would be required for the surface current produced by the wind to be transmitted in one half its intensity to a depth of 100 metres. Recently Ekman has put forward a theory which takes account of the earth's rotation. This leads to results entirely different from Zoeppritz's. Thus the surface current flows in a direction 45° to the right hand (in the northern hemisphere) of the wind, and at successive lower layers the direction becomes more and more to the right, until it is directly opposed to the wind at a depth D where the velocity is one-twentieth of its surface value. This is in an infinite ocean of considerable depth. The depth at which this complete reversal occurs depends on μ , the coefficient of viscosity, the value of which must be modified to take account of the turbulence between adjacent layers of water. The value of D is then found to be 75 metres. Other problems are dealt with in the same way, where the infinite ocean of considerable depth is replaced by certain other assumed conditions. An application of these theoretical results to the general conditions prevailing along the west coast of N. America gives good qualitative agreement with the observed facts, the low sea temperature being accounted for by the upflow of cold water from the outlying sea bottom. This upflow would be expected from an application of the theory to the local conditions. Monthly surface sea temperatures are calculated for four stations making use of the known mean monthly wind velocities, and good agreement is obtained between the observed and calculated values. The paper concludes with an examination of the relation between the surface sea temperature and that of the adjacent land. J. S. Di.

30. *Axial Variations in the Earth as the Cause of Earthquakes.* R. Spitaler. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 479-501. March, 1913.)—The author commences by referring to Milne's work on "Seismological Observations and Earth Physics" (Geographical Journal, 1908). In this Milne shows that the number of earthquakes increases with the size of the polar changes, and that rapid directional movements coincide with greater earthquake frequency. The present author therefore considers that by the study of axial fluctuations an explanation of terrestrial surface changes may be found, and his paper is a mathematical discussion of the axial movements, the results of which are supported by earthquake data. As an example of the latter the case of the two great San Francisco earthquakes may be quoted where prior to the catastrophe the polar movement underwent a rapid change in direction, so that this constituted the primary phenomenon whereas the earthquake itself was secondary. H. H. Ho.

31. Spectrographic Measures of Solar Rotation. J. Evershed and T. Royds. (Roy. Astronom. Soc., M.N. 78. pp. 554-562, June, 1918.)—During the dry seasons of 1911 and 1912 at Kodaikanal advantage was taken of days of exceptional clearness, when the sky appeared quite clear from diffuse cirrus cloud, to obtain high dispersion spectra of the east and west limbs of the sun and of the centre of the disc, for the purpose of studying the displacements towards the red of certain lines of iron and nickel at the sun's limb. These measurements gave values of the rotation decidedly smaller than those obtained by Adams in 1908. In the autumn of 1912 preparations were made for a new series of comparisons, the spectra of the two limbs and centre to be exposed simultaneously in order to avoid any instrumental error. Meanwhile the observations by Hubrecht at Cambridge were published, these agreeing closely with the Kodaikanal values in two respects: (1) the lower equatorial velocities, and (2) the variation between plates obtained at different dates. In view of a real change of velocity between epochs of maximum and minimum the new series were obtained during the early months of 1918. Three series were obtained in the period 1918 Jan.-April. Grouping the results of these a progressive change of velocity is clearly indicated, varying from 1·990 to 1·900 km./sec. This would indicate that it is not possible to derive reliable measures of the equatorial velocity from observations extending only over a few months. There appears to be a connection between rotation speed and sun-spot disturbances, probably dependent on proper motion of the vapours in the reversing layer, times of max. spot development being associated with large proper motion in the direction of the solar rotation.

C. P. B.

32. Anomalous Dispersion in Solar Phenomena. D. Brunt. (Roy. Astronom. Soc., M.N. 78. pp. 568-600, June, 1918.)—Three theories of the equilibrium of the solar atmosphere are considered, but it is concluded that they cannot account for an atmosphere extending to the actual height observed. The effect of anomalous scattering is completely masked by the true absorption effect. The observed differences between the Fraunhofer lines at the centre and limb of the sun do not agree with the requirements of the anomalous refraction theory. It is also shown that anomalous refraction, whether the solar atmosphere has a tubular structure or a system of irregular density gradients, cannot account for the double bright reversal of H and K which is observed over the whole disc, and particularly over the calcium flocculi. As regards the chromosphere and prominences, no definite criterion could be found to decide between the anomalous dispersion theory and the selective emission theory. In the case of all the other phenomena the criteria available are unfavourable to the idea of anomalous dispersion having any important effect in solar phenomena.

C. P. B.

33. Interpretation of Photospheric Phenomena. W. H. Julius. (Astrophys. Journ. 88. pp. 129-140, Sept., 1918.)—In presenting a discussion of various views concerning the nature of the solar photosphere, a new dioptrical interpretation is suggested, attributing many of the phenomena to a modification of ray-curving by gases having certain density gradients.

C. P. B.

34. General Magnetic Field of Sun. G. E. Hale. (Astrophys. Journ. 88. pp. 27-98, July, 1918.)—Since the classic experiment by Rowland of producing a magnetic field by rotation of an electrically charged disc [Abstract No. 781 (1918)], various views as to the causation of terrestrial magnetism have

been formulated, and the author presents a short summary of these publications. So many ideas connected with the solar phenomena depend for their satisfactory explanation on the view of the sun acting as a magnet that a very rigid determination was planned with the powerful spectrographic equipment of the Mount Wilson Solar Observatory. The only method of direct observation consists in the examination of the Zeeman-effect on solar spectrum lines. If the field be strong enough, and the observer is supposed to be looking along the sun's axis, certain of the lines would be split into doublets, with components circularly polarised in opposite directions. For the investigation of this the solar light is passed through a Nicol prism and a quarter-wave plate before it reaches the slit of the spectrograph. In practice, on account of the weakness of the sun's magnetic field as compared with the field of sun-spots, complete separation into doublets is not to be expected; and, further, the observer is generally looking in directions considerably removed from that of the sun's axis. The most favourable position for observation is latitude 45° , where the effect of the ellipticity of the light of the components is overcome by the increased strength of the field. After a long analysis of the observed displacements, it is concluded that the results are in harmony with the idea that the sun is a magnetised sphere. On the assumption that the magnetisation is due to rotation, the sun's charge would be negative, the polarity corresponding to that of the earth. The determined strength of the field at the sun's pole is 50 gauss. A further extended investigation of the solar magnetic field at various levels is to be made in the near future, and will be carried on throughout the sun-spot cycle to ascertain if any variation occurs in relation to that of the sun's activity.

C. P. B.

35. Displacement Curve of Sun's Magnetic Field. **F. H. Seares.** (Astrophys. Journ. 88. pp. 99-125; July, 1918.)—In a recent paper [preceding Abstract] Hale has described the results of an investigation for determining whether the sun possesses a general magnetic field similar to that surrounding the earth, the conclusion being in favour of its existence. In order that there might be a more rigorous control of the results, the observed displacements have been compared with the theoretical displacement curve derived on the assumption that the sun is a magnetised sphere, this investigation being the basis of the present paper. The equation connecting the displacement of a spectrum line with the solar magnetic elements, the co-ordinates of the observer, and the observed point, was established. The discussion is restricted mainly to the case of the simple Zeeman triplet. The effect on the displacement curve, of the elliptic polarisation introduced by the reflections from the silvered surfaces of the coelostat mirrors is also fully considered. It is found that for a normal Zeeman triplet the theoretical displacement curve is a function of the heliographic latitude, the position of the observer, and the solar magnetic elements, and is a sine curve differing but little from $k\Delta = 8 \sin 2\phi$, where k is a constant depending upon the units and the field strength at the sun's magnetic equator. This will give zero values near the equator and the poles, and maxima near 45° N. and S. The effect of the elliptical polarisation of the coelostat mirrors is to flatten by a negligible amount the curve of displacements.

C. P. B.

36. Origin of Solar Electricity. **J. A. Harker.** (Roy. Astronom. Soc., M.N. 78. pp. 562-567, June, 1918. Chem. News, 108. pp. 261-263, Nov. 28, 1918.)—The author refers to his experiments on the emission of electricity from carbon inside an electric furnace [see Abstract No. 1417 (1912)].

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Positive electricity was emitted at temperatures from 1000° to 1400° C. With those metals which melt within this range a sudden increase in the positive current occurred at the liquefying point. At higher temperatures negative electricity predominates, and its quantity increases rapidly with the temperature.

Applying these facts to the sun, it would suggest that the solar atmosphere is a highly conducting medium. The modern values of its temperature range from 5600° to 6000° abs. It may thus be that in the solar atmosphere there are very large numbers of electrified particles, by the movements of which enormous currents are generated. C. P. B.

37. Diffraction Phenomena at Solar Eclipses. F. Biske. (Astrophys. Journ. 88, pp. 192-196, Sept., 1918.)—An analysis is made of the conditions during a total solar eclipse to determine if it may be possible for the dark "shadow bands" to be due to diffraction at the moon's limb.

The conclusion is that the phenomenon is not due to diffraction. C. P. B.

38. Variations of Solar Atmosphere. H. Deslandres and L. d'Azbujaja. (Comptes Rendus, 157, pp. 418-421, Sept. 1, 1918.)—During the progress of the sun-spot cycle it has been noticed that the various solar phenomena have not been in unison as regards diminution with the gradual disappearance of the spots. In particular the peculiar polar alignments have been very prominent during the last two years. Diagrams are given showing the relation between the visible phenomena during specially selected rotations in 1912 May, 1912 Oct., and 1913 Feb., the latter including a spot with somewhat high latitude suggesting the commencement of the new cycle. While the spots and filaments have been very sparse, the alignment network appears to have persisted throughout, and it may be that this is a permanent feature of the solar atmosphere. C. P. B.

39. Harmonic Analysis of Wolf's Sun-spot Numbers. H. H. Turner. (Roy. Astronom. Soc., M.N. 78, pp. 549-552, May, 1918.)—The paper is in part a criticism of Kimura's analysis [see Abstract No. 1796 (1918)], and also in continuation of the work noted in Abstract No. 575 (1918). Kimura's paper purported to be a complete identification of a number of periodicities, grouped in periods of 162, 78, 60, and 50 years. Examination of the coefficients of the series used in the analysis leads to the conclusion that their methodical run is merely a consequence of the *regularity* of the series of Wolf's numbers. C. P. B.

40. Rotation of Jupiter. H. E. Lau. (Astronom. Nachr. No. 4678. Review by A. S. Williams in Observatory, No. 465, pp. 878-875, Sept., 1918.)—The article is a review of a paper by H. E. Lau, giving a summary of observations made at Copenhagen during the 6 years 1905-10 with a 10-in. refractor. A table is given showing the mean values of the drift of the surface material of the planet in different latitudes, combined with the results of two years' observations by H. Struve with the 18-in. Königsburg refractor during 1908-4. All the results were obtained by direct measurement with the micrometer. The reviewer compares these results with those made by various observers during the 20 years 1887-1906. Several discordances are apparent, the chief one being with respect to the Great Equatorial Current, which is shown by the longer series of
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results to drift at substantially the same rate throughout its whole breadth, though near its northern border the rate is somewhat slower than that of the current in general.

C. P. B.

41. *Energy in Planetary Motions.* A. Gray. (Nature, 91. pp. 581-582, Aug. 7, 1918.)—If a particle be brought from infinity by the action of a central attraction varying as the inverse square of the distance to a circular orbit about the centre, or transferred from one circular orbit to another, half only of the potential energy exhausted is represented by the orbital motion, so that half the work must have been expended in overcoming resistance of some sort. The author here states and proves the corresponding theorem in elliptic motion, viz. the time-average of the kinetic energy, taken for one revolution in the orbit, is half of the corresponding time-average of the potential energy exhausted in the passage from infinity to the distance r , with a similar theorem for the difference of energy when the particle is transferred from one orbit to another about the same centre. If the orbit be an hyperbola of which $2a$ represents the distance between the vertices, the kinetic energy at distance r exceeds the potential energy exhausted in the transference from infinity to that distance by the mean kinetic energy of the motion in an ellipse of semi-major axis a . Thus if a planet formed in the course of condensation of a nebula is to have an hyperbolic orbit, it must, by an internal explosion, or some other convulsion or process, have a quantity of kinetic energy given to it in excess of that produced by the transference of the matter from infinite dispersion in space. In the evolution of planets according to the nebular hypothesis hyperbolic orbits would thus be exceptional cases.

G. W. DE T.

42. *Motions and Distances of Pleiades and other Star Groups.* H. C. Plummer. (Roy. Astronom. Soc., M.N. 78. pp. 492-499, May, 1918.)—An attempt has been made in former papers [Abstract No. 1615 (1918)] to exhibit the general character of the galactic motions of stars of Type I for which radial velocities are known. It has been shown at Mount Wilson that all local groups of stars, for which the necessary data are available, move in space nearly parallel to the Milky Way. Examination has been made of the Pleiades, and of groups of stars in the constellations Vela, Perseus, and Centaurus-Scorpio, with the general result that no large component *normal* to the plane of the Milky Way has been detected.

C. P. B.

43. *Motion of the Stars.* C. V. L. Charlier. (Roy. Astronom. Soc., M.N. 78. pp. 486-491, May, 1918.)—Advance notes of a research on the motions of the stars to be published in a future communication from the Lund Observatory. The *true apex* is found to be $RA = 278^{\circ}17' \pm 2^{\circ}06'$; $Decl. = +81^{\circ}15' \pm 1^{\circ}76'$, as derived from the proper motions of the stars of fifth magnitude. Using Campbell's value of the solar velocity (20 km. per sec.), the mean parallax of the fifth magnitude stars is $0.01126'' \pm 0.00072''$. The true vertex does not coincide with the apparent vertex, but the apex, apparent vertex, and true vortex always lie on the same great circle.

C. P. B.

44. *Spectra of Novæ and Pressure Effect.* W. G. Duffield. (Roy. Astronom. Soc., M.N. 78. pp. 631-645, June, 1918.)—Dealing with the points of resemblance between the spectra of Novæ and metals under pressure, the

subject is dealt with in regard to the doubling of the lines, their broadening, the intensity curves and structure of the broadened lines, the reversal and relative intensities of the lines. The difficulty of accepting the theory outlined is owing to their being no explanation of the enormous velocities indicated by the displacement of the dark lines. [See Abstract No. 1649 (1899).] C. P. B.

45. *Spectrum of Nova Geminorum* (1912). **A. L. Cortie.** (Roy. Astronom. Soc., M.N. 78. pp. 646-652, June, 1913.)—Photographs of the Nova spectrum were obtained in March and April, 1912, with the Hilger compound prism attached to the 15-in. equatorial refractor, and during the early months of 1912 with a 6-in. objective prism made by Thorp for the 6-in. Dallmeyer portrait lens given to the Observatory by E. T. Whitelow. The details of the spectra are tabulated in comparison with those obtained at Mt. Wilson by Adams and Kohlschütter, showing good agreement. It is concluded that the dark-line enhanced spectrum of March, 1912, became mainly a bright-line spectrum in April. The most prominent feature of the 1912 spectra was the series of bright nebular bands at $\lambda\lambda 4069, 4863, 4637, 5007$. Other bright lines were present, including enhanced lines of Ti and Sn. This permanence of chromospheric lines suggests that the phenomenon may be due to a chromospheric outburst on a large scale in a nebulous star. C. P. B.

46. *Variable Stars of Cluster Type.* **H. C. Plummer.** (Roy. Astronom. Soc., M.N. 78. pp. 652-660, June, 1913.)—The variable stars which have been found in clusters belong mainly to a certain well-marked type, the most characteristic feature being the extremely short period of variation. Certain of these stars are discussed analytically, and the general possibilities of the various theories advanced for their explanation examined. No very decided conclusion is possible, but it is suggestive that there appears to be some evidence of their being of the spectroscopic binary type. C. P. B.

47. *Orbits of Eclipsing Binaries.* **H. Shapley.** (Astrophys. Journ. 88. pp. 158-174, Sept., 1913.)—A summary is given of numerous publications dealing with the problem of eclipsing binaries [see Abstracts Nos. 890, 947, 1614 (1913)]. Special attention is given to the differences of brightness and size of the components of such systems; in most cases the large faint star has been found to be redder than the brighter component, suggesting that they are of a later spectral type. C. P. B.

48. *Stellar Parallaxes.* **F. Slocum and S. A. Mitchell.** (Astrophys. Journ. 88. pp. 1-26, July, 1913.)—Tables are given of a series of parallax determinations on fourteen stars made from photographs taken with the 40-in. refractor of the Yerkes Observatory. C. P. B.

49. *Observations of Variable Star, 97.1910 Cygni.* **E. E. Barnard.** (Roy. Astronom. Soc., M.N. 78. pp. 500-518, May, 1913.)—Discovered by Hinks on plates taken in Aug., 1909, this star was at first thought to be a Nova, but later observations now suggest that it is a variable of long period, about nineteen or twenty months, with a range of about six magnitudes in brightness. Details are given of the measurements throughout a long series of comparisons extending to 1913, April 14. C. P. B.

50. *Photographic Star Magnitudes.* (Roy. Astronom. Soc., M.N. 78. pp. 518-524, May, 1913. From the Royal Observatory, Greenwich.)—The VOL. XVII.—A.—1914.

paper deals with the corrections depending on the distance of the star image from the centre of the plate, necessary for determining star magnitudes from photographs taken with the Greenwich Astrographic Equatorial. This is of special importance, as the standard stars of the Harvard sequence fall on a comparatively small area in the centre of the plate. A sensitive method of determining these corrections is afforded by counting the relative numbers of stars photographed in different parts of the plate. It is found that the area of best definition is an annulus, the zone of max. intensity being at $40'$ from the axis.

C. P. B.

51. *Stellar Photometry with Photoelectric Cell.* W. F. Schulz. (Astrophys. Journ. 88. pp. 187-191, Sept., 1918.)—Encouraged by the great sensitiveness obtainable with the photoelectric cell [see Abstracts Nos. 1411 (1912), 1327 (1913)] the author has made experiments with the object of determining the relative intensity of star radiation and detecting any variation of the star-light. The cell used had a Pt-wire anode, with a layer of metallic potassium for the cathode. In Dec., 1912, the light from the star α Aurigæ (Capella) was measured, and in April, 1918, that from α Bôotes (Arcturus), using as light collector the 12-in. equatorial of the University of Illinois. With 40 volts on the needle and 160 volts on the cell, the rate of deflection at a scale distance of 2 m. was 20 mm. in 80 secs. With 200 volts on the cell, the rate was 18 mm. in 20 secs. Further experiments are to be made in order to compare the action of the photoelectric cell with that of a selenium cell.

C. P. B.

52. *Spectrum of α Canum Venaticorum.* A. Bêlopol'sky. (Astronom. Nachr. No. 4681. Nature, 92. pp. 148-144, Oct. 2, 1918. Abstract. Acad. Sci. St. Pétersbourg, Bull. 12. pp. 689-704, Sept. 15, 1918. Observatory, No. 467. pp. 482-485, Nov., 1918.)—As reported previously [Abstract No. 1688 (1918)], the spectrum of this star shows striking variations of a periodic nature. In the present paper a discussion is given of 67 spectrograms secured in the interval April 15 and June 18, 1918, with the three-prism spectrograph attached to the 80-in. refractor. From measures of the line $\lambda 4180.0$ he finds a period of 5.50 days. Another set of lines appears to vary inversely with $\lambda 4180$, while lines of hydrogen, Mg, Ca, and Fe display little change.

C. P. B.

53. *Spectrum of Wolf Rayet D.M. + 80-8689°.* P. W. Merrill. (Lick Observatory, Bull. No. 280. Nature, 92. p. 109, Sept. 25, 1918. Abstract.)—Results are given of the details in the red end of the spectrum of this interesting star, of photographic magnitude 10.0. In addition to the ordinary Wolf-Rayet lines two others are shown near H α .

C. P. B.

54. *Variation of RU. Camelopardalis.* H. Shapley. (Laws Observatory, Bull. No. 21. Nature, 92. p. 86, Sept. 18, 1918. Abstract.)—Discussion of the photometric measures of the star, resulting in the conclusion that the light-variations can be accounted for on the hypothesis of a single, uniformly luminous, ellipsoidal body rotating in a period of 44.844 days. The spectrum of the star is peculiar and apparently variable, possibly belonging to Class N.

C. P. B.

55. *Energy of Nebulae and Carnot's Principle.* H. Block. (Comptes Rendus, 157. 101-103, July 15, 1918.)—According to Arrhenius, Carnot's

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principle is inapplicable to nebulous gases, since, owing to the attenuated value of gravity, those molecules of high speed will escape from the nebula and form a hotter zone, whereas the nebula, only retaining the molecules of small velocity, will cool down. Schwarzschild (*Astrophys. Journ.* 37. p. 297, May, 1918) has recently published a very interesting calculation on this point, and arrived at the remarkable result that the escaped portion will possess a lower temperature than the initial temperature of the nebula. The author has taken up the mathematical study of this problem with the object of minutely examining Schwarzschild's calculations, and assumes the velocities of the molecules near the surface to be distributed according to Maxwell's law. Schwarzschild's result is verified. In every case the escaped mass will cool, as also the residue, but the final energy condition is more favourable than the initial since there is a gain in potential energy, and the difference between the temperatures represents a more favourable partition of energy. The ratio of the number of molecules escaping to those which remain is found to be 0.456 : 0.544. A calculation is then made as to the dimensions necessary for a spherical nebula in order that these conditions may be realised, and the radius for the special case of hydrogen at 50° C., is found to be 8250 M, where M is the mass of the nebula in solar units, the unit of length being the radius of the terrestrial orbit. Although the phenomenon pointed out by Arrhenius is not the ability for one part of the nebula to become warm at the expense of the other, there may, under favourable circumstances, be a conversion of considerable quantities of thermal energy into a form more useful.

H. H. HO.

56. *Variable Nebulæ.* G. Bigourdan. (*Comptes Rendus*, 157. pp. 421-423, Sept. 1, 1918.)—The author suggests the more detailed publication of observations of *nebulæ*, in order to provide material for the detection of any possible variability. Attention is directed to a nebula discovered by Hind in 1845 [G.C. 4478 (NGC. 6760)], which has been suspected of variability, and which Bonelly has recently observed with a telescope of only 0.165 m. aperture.

C. P. B.

LIGHT.

57. *New Prism with Curved Faces.* A. Callier. (*Zeitschr. Instrumentenk.* 83. pp. 22-24, Jan., 1913.)—The new prism, designed to avoid the use of lenses in a spectroscope, is a modification of one designed by Féry. In Féry's prism the first face in section is theoretically a logarithmic spiral, replaced in practice by a circular arc. The refracted rays entering the prism undergo internal reflection at a second face, and then emerge again at the same face through which they entered, the curvature of the reflecting face being so calculated that a real image of the slit is finally formed close to the original source. This prism suffers from the following disadvantages: (1) There is generally considerable loss of light by reflection. (2) The image and the source being in proximity, the deviation is not minimum, and the definition suffers. (3) Since the rays enter and emerge at the same face, there can be no magnification of the spectrum. In the new prism, devised to overcome those defects, three faces come into play, the first and third, where the rays enter and emerge respectively, being both theoretically in section arcs of logarithmic spirals, while the second face where the rays are reflected internally is an elliptic arc, one focus of which is the virtual image of the source in the first face, the other focus the corresponding point for the final image and third face. In this arrangement the reflection is total, and the deviation minimum, and by giving different curvatures to the first and third faces, the spectrum can be magnified or diminished. The firm Adam Hilger, Ltd., at the author's request, undertook some experiments with the new prism, the theoretical surfaces being replaced in practice by spherical ones. The definition was found to be satisfactory, but there was considerable astigmatism, as in the case of the concave grating, and Féry's prism. A spectrogram of the copper arc taken with it is reproduced in the original article. A. E.

58. *Plane Grating for Stellar Spectroscopy.* J. S. Plaskett. (*Astrophys. Journ.* 87. pp. 378-379, June, 1913.)—Previous investigations on the performance of grating spectrographs on stellar spectra have been made by Poor and Mitchell, and Wadsworth [see Abstract No. 612 (1898)], but the method has not been generally adopted owing, probably, to the loss of light in the various orders. Efforts have been made at various times to produce gratings having a greater portion of the light concentrated in some one spectrum, and in such cases it might be possible to construct a spectrograph of high efficiency compared to the three-prism spectrographs, where the long path through dense flint results in much absorption of the violet radiation. A grating has been obtained, ruled by Anderson, of Johns Hopkins University, having ruled surface 7.4×9.4 cm., 15,000 lines to the inch, which is estimated to diffract about 50 % of the light returned by the speculum metal surface into one first order. Tests were made on stellar and solar spectra with grating and prism spectrographs of about equal dispersion. One of the most striking features of the grating spectra is the comparative uniformity in intensity between $H\beta$ and $\lambda 3850$. The weakness of the spectra will be a disadvantage unless the concentration of light in one order can be still further increased, but the system should be of service where spectra down to the K line ($\lambda 3988$) are required. C. P. B.

59. Absolute Measurement of Ultra-violet and Visible Radiations. C. Winther. (*Zeitschr. Elektrochem.* 19. pp. 389-397, May 1, 1913.)—The instrument, the fluorometer, consists of a glass box, 5 cm. long, filled with a very dilute solution of some fluorescent material (rhodamine, sodium fluorescein known as uranin, quinine sulphate). To the right is the standard lamp, a 16-c.p. Osram lamp with simple loop; to the left the light to be tested. Two beams of light enter through stops, from the right and the left, and form two parallel fluorescent light-bands, the intensity in each band decreasing from the entrance to the opposite wall. By means of a sliding lens and a cross-wire attached to the top of the box the position is determined at which the intensities of the two bands are equal. This measurement, together with the known extinction coefficients for the respective wave-lengths, gives the required energy. The extinction coefficients were determined with the aid of monochromatic light (Hilger quartz spectrograph) and a potassium photo-electric cell (of Elster and Geitel); the calibration in absolute units was done by E. S. Johansen. The author tests various light filters with his fluorometer, studies the energy distribution in spectra, and recommends his instrument, which is supplied by the Aktieselsk. Dansk Telegrafonfabrik, of Copenhagen, also for the determination of reaction velocities. H. B.

60. Correction of Field of Newtonian Telescope. R. A. Sampson. (*Roy. Astronom. Soc., M.N.* 78. pp. 524-527, May, 1913.)—The paper deals with a proposed method of correcting the geometrical defects of the Newtonian reflector by the interposition of three thin lenses of the same kind of glass. C. P. B.

61. Refraction and Dispersion of Gaseous Nitrogen Peroxide. C. Cuthbertson and M. Cuthbertson. (*Roy. Soc., Proc. Ser. A.* 89. pp. 861-869, Nov. 1, 1913.)—By means of a Jamin's refractometer, the refractivity of pure NO_2 , for $\lambda = 6438$, reduced to standard conditions by the formula $(\mu - 1)_{0.76} = \text{N}\lambda/L$. $1/278.76/p$, is found to be approximately 0.000509. That of pure N_2O_4 is 0.001123, so that the effect of polymerisation is to increase the refractivity by about 10.5 per cent. The refractivity of a molecule of NO_2 is greater than those of its constituent elements by 21 per cent. The dispersive power of a molecule of NO_2 in the red and green is considerably greater than that of a molecule of N_2O_4 . T. H. P.

62. Electric and Magnetic Double Refraction. W. Voigt. (*Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse*, 2. pp. 215-220, 1913.)—Mathematical discussion concluding with a result in agreement with Sommerfeld's derived from consideration of the emission of a system of electrons in a magnetic field. [See Abstracts Nos. 800 and 1151 (1913).] E. H. B.

63. Propagation of a Luminous Signal in a Dispersive Medium. L. Brillouin. (*Comptes Rendus*, 157. pp. 914-916, Nov. 17, 1913.)—A mathematical investigation employing Fourier's integrals. The author finds that the velocity of the signal is assimilated to that of the group for all signals whose periods correspond to a normal dispersion. The values of the two velocities differ in the region of anomalous dispersion. The velocity of the signal is always lower than that of light *in vacuo*. E. H. B.

64. Fresnel's Diffraction Phenomena. W. Arkadiew. (*Phys. Zeitschr.* 14. pp. 882-885, Sept. 1, 1913.)—Gives a number of photographs representing VOL. XVII.—A.—1914.

diffraction phenomena as studied from the time of Grimaldi and Fresnel down to the eighties, when the new form of Huyghen's principle presented by Kirchhoff inaugurated a new era. The source used is a slit 1 mm. wide, and the photographic plate was at a distance of 89 m. from the object casting a shadow.
E. E. F.

65. *Interferometer in Rotation demonstrates a Relative Ether Wind.* G. Sagnac. (Comptes Rendus, 157. pp. 708-710, Oct. 27, 1918.)—In this experimental research a horizontal plate 50 cm. in diameter rotates uniformly about a vertical axis N times (once or twice) per sec. This plate carries the various parts of an interferometer, including the source of light (an electric lamp) and the receiver (a fine-grained photographic plate), which records the interference bands at the focus of a lens. The two interfering pencils, reflected by four mirrors, are superposed in inverse senses round the same horizontal circuit enclosing a certain area S . On the photographs d and s , obtained respectively during a *dexter* or *sinister* rotation of the plate at the same rate, the centre of the central fringe shows two positions. This displacement, z , of the system of bands is then measured. The author derives the relation $z = 16\pi NS/\lambda V_0$, where λ is wave-length of the light used and V_0 the speed of light in vacuum. For the indigo light used, $N = 2$ per sec., $S = 860$ cm.², z was 0.07 cm. and showed well with bands under 1 mm. wide.
E. H. B.

66. *Constancy of the Velocity of Light.* E. Freundlich. (Phys. Zeitschr. 14. pp. 835-888, Sept. 1, 1918.)—A reply to de Sitter's alleged proof [Abstract No. 1418 (1918)] of the constancy of the velocity of light from considerations of double-star orbits. He admits that observations speak at all events against the velocity of the source being simply added to the ordinary velocity of light, but some fraction of it might be added. The discrimination of such an addition would be difficult, especially as each observer takes Kepler's laws for granted and seeks to range his observations into a curve which fits them best. But it is notorious that many binaries show an eccentricity which is directed in the line of sight in a manner quite inconsistent with a fortuitous orientation of orbits. Miller Bar enumerates 28 systems out of 28 taken at random, and 7 out of 8 with an eccentricity greater than 0.5. Certain disturbances in the velocity of revolution, hitherto attributed to perturbation by a third body, may be due to inconstancy of the velocity of light. Spectroscopic binaries of accurately known parallax are the most promising material, but at present the question is still open. [See also Abstract No. 884 (1910).]
E. E. F.

67. *Pressure of Radiation on Small Reflecting Sphere.* J. Proudman. (Roy. Astronom. Soc., M.N. 78. pp. 585-589, May, 1918.)—The previous discussions of this problem by Schwarzschild and Nicholson are not in complete agreement [see Abstract No. 1108 (1910)], and the problem has again been worked through by the present writer. His new results are in substantial agreement with those of Nicholson, except with regard to the max. pressure, and the details concerning this maximum are included in this paper.
C. P. B.

68. *Doppler Principle and Relativity.* K. Tamaki. (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 215-284, May, 1918.)—A theoretical treatment which may be summarised as follows:—The Doppler-effect due to the motion of an
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observer and a light source is calculated in the usual manner. As is well known, the results of the two cases are different. The assumptions tacitly made in the usual calculation are pointed out.

Rejecting one of the assumptions and trying to harmonise the result with the first postulate of the principle of relativity as to the change of frequency in the two cases, it is shown that one of the three following hypotheses must be introduced : (i) The *emission* hypothesis, which states that the velocity of light from a moving source is $c + v$, v being the velocity of the source and c that of light when the source is at rest. (ii) The *frequency* hypothesis, which states that the frequency of light-waves emitted by a moving source is $n = n_0 [1 + (v/c)^2]$, where n_0 is the frequency of light when the source is stationary, c and v having the same meanings as in (i). (iii) The *different-units* hypothesis which states that between the units of time T , and T_m adopted by a stationary observer and a moving one there is the relation—

$$T_m = T \cdot 1/\sqrt{1 - (v/c)^2}.$$

It is proved that the first hypothesis must be rejected when we consider the change of wave-length, and the second hypothesis when the case of the Doppler-effect due to a moving mirror is considered. Thus it is concluded that the first and second postulates of Einstein's Principle of Relativity are in no conflict. The change of length due to motion is shown to follow from that of the unit of time. The Lorentz-Einstein transformation equations are derived most simply from the first postulate and the change of length. [See Abstract No. 2277 (1905).] E. H. B.

69. *Objective Photometry.* W. E. and R. Pauli. (Ann. der Physik, 41. 4. pp. 812-828, July 17, 1918.)—Reference is made to Langley's researches on coloured light, the results of which are criticised on several grounds, notably the fact that the lights were compared on an acuteness-of-vision basis. The authors describe researches comparing red and green light with a lens-flicker photometer. The methods of obtaining approximately pure red and green light are described, and the absorption curves of various filters given. Bolometric tests of the corresponding energy values were also undertaken. The authors reach the conclusion that the eye (bright adapted) is 960 times as sensitive to green light (546 $\mu\mu$) as to red light (660 $\mu\mu$). But the result is affected by the state of adaptation of the eye. For dark adaptation the corresponding ratio was 1640, for central vision 590. The authors also experimented with mixtures of light. They point out that it is possible to have two equally luminous fields of exactly the same colour and saturation, but the energy required to produce a given brightness may be widely different. For these reasons objective photometry, which avoids the complexities of the eye, is impracticable. J. S. D.

70. *Absorption of Light by Inorganic Salts.* IX. *Solutions of Copper, Nickel, and Cobalt Salts in Alcohol and in Acetone.* R. A. Houstoun and A. H. Gray. (Roy. Soc. Edinburgh, Proc. 88. pp. 187-146, 1912-1918.)—When copper, nickel, and cobalt salts are dissolved in alcohol or acetone their absorption is much greater, and also more characteristic of the molecule, than when they are dissolved in water. The addition of water to alcoholic solutions of copper chloride produced a small initial increase of absorption, followed by a large and progressive decrease. In the case of copper bromide, VOL. XVII.—A.—1914.

the addition of a single drop of water to 8 c.cm. of the alcoholic solution reduced the absorption coefficient almost to its value for solutions in water. Solutions of anhydrous cobalt bromide in alcohol showed a progressive decrease of absorption of light of wave-length $\lambda = 628 \mu\mu$ as the colour changed from blue to pink by the addition of water. Curves for three concentrations would intersect at abs. coefft. $A = 215$ if extrapolated to concentration -0.4% water; it was assumed that this represented the quantity of water originally present in the alcohol. Application of the law of mass-action on the assumption that $A = 215$ in anhydrous alcohol gave values ranging from 6.1 to 9.2 for the number of water-molecules which must be assumed to combine with the salt in producing the change of colour: it is therefore suggested that this change is probably due to the conversion of the anhydrous salt into the known hexahydrate.

T. M. L.

71. Absorption of Light by Inorganic Salts. X. R. A. Houstoun and C. Cochrane. (Roy. Soc., Edinburgh, Proc. 88. pp. 147-155, 1912-1918.)—

(1) The acetate and sulphate give similar absorption curves in the case of cobalt and nickel, but not in the case of copper, of which the acetate gives a much greater absorption in the red. It is suggested that copper acetate may have a different chemical constitution. (2) Ionisation has nothing to do with the colour-changes of cobalt, nickel, copper, and iron salts. The molecular extinction coefficients are only changed to any large extent at certain "sensitive-points" of the spectrum. Of these points, the molecular extinction-coefficients are constant at low concentrations and increase asymptotically as saturation is reached; this is quite different to the behaviour of the coefficients of ionisation, so that there is no connection between the two quantities. (3) The effect of adding water to an alcoholic solution of cobalt chloride has been shown (in Part VI) to be attributable to the formation of a hydrate. Solutions in acetone give a similar absorption-curve, but the effect of adding water is quantitatively very different. It is suggested that the anhydrous salt combines with the acetone. (4) The abnormal behaviour of cobalt and nickel iodides is due to formation of oxyiodides with liberation of iodine.

T. M. L.

72. Absorption of Light by Inorganic Salts. XI. Conclusion. R. A. Houstoun. (Roy. Soc. Edinburgh, Proc. 88. pp. 156-165, 1912-1918.)—

The absorption spectra of aqueous salt-solutions appear to be influenced very little by the linkage between the positive and negative radicals. The view is advanced that the three bands characteristic of the nickel salts and the two bands characteristic of the cobalt salt are due to the association of the metallic radicals with a watery atmosphere, which is only slightly affected when ionisation occurs.

Attempts to apply electronic theories have met with but little success. Only in the case of water has a dynamical model been invented which satisfies the experimental observations by giving a ratio 2.82 for the ratio of wave-lengths of two bands instead of 2.00, and 7110 or 1550 for the value of c/m instead of 9660.

Theoretical generalisations are difficult, in part because they must cover so wide a range, e.g. values of A , the extinction coefficient, ranging from 27,000 to 0.01 and wave-lengths from 0.28μ to 1.8μ .

T. M. L.

73. Wood's Method of Discovering Spectrum Laws. A. Afanassieff and D. Roschdestwensky. (Phys. Zeitschr. 14. pp. 780-788, Aug. 15, 1918.)—

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Describes a new modification of this method [Abstract No. 1662 (1913)]. White light from an arc lamp falls upon the vertical slit of an echelon grating of 1 cm. step and 1 mm. width. The diffraction pattern is thrown upon the narrow vertical slit of an auto-collimating grating spectrograph. This yields fine vertical bright lines, whose distance apart depends upon the echelon constant. On placing the echelon with its slit horizontal, the lines are slightly inclined. By widening the slit of the spectrograph symmetrically, each of the inclined lines may be drawn out into a strip in a horizontal direction, and the strips remain separated by dark lines. Each of these strips represents a piece of spectrum in the echelon dispersion, and any regularities are at once evident by a curve or pattern in the whole trace. The regularities are well illustrated by the absorption spectrum of iodine. E. E. F.

74. *Absorption Bands of Acetone.* J. Stark. (Phys. Zeitschr. 14, pp. 845-847, Sept. 1, 1918.)—Shows that if there is a point of inversion in an absorption curve, it indicates the existence of a feeble band within the wave-length area of the principal band. Both the work of Gelbke and that of Bielecki and Henri [Abstract No. 1819 (1918)] indicate that acetone has, besides the short-wave band, a much less intense ultra-violet absorption band of a wave-length above 330μ . E. E. F.

75. *Arc and Spark Spectrum of Oxygen Canal Rays.* J. Stark, G. Wendt, and H. Kirschbaum. (Phys. Zeitschr. 14, pp. 770-779, Aug. 15, 1918.)—The authors study the question whether the ratio of the intensities of the arc and spark lines of oxygen changes with the cathode-fall producing the canal rays; also, whether there are several distinct speeds of canal rays, indicating different valencies. The results show that on increasing the cathode-fall from 3200 volts to 15,000 volts the stationary and the moving intensities of the spark lines increase considerably, whereas the series lines almost disappear. The spark lines 4190.0 \AA . and 4076.2 \AA . show distinct traces of a point of inflection in the intensities of their motion spectra, indicating three distinct velocities. Further evidence is adduced for the existence of two distinct types of spark lines, one of which is sharp, while the other is diffuse. The latter represents a valency one unit higher than the former. The authors also distinguish two distinct arc spectra, and believe that the bearer of one of these is the positive univalent O_2 -molecule. E. E. F.

76. *Ultra-violet Spark Spectra of Metals.* J. M. Eder. (Akad. Wiss. Wien, Ber. 122. 2a, pp. 607-688, March, 1918. Zeitschr. wiss. Phot. 18. 1, pp. 20-40, Nov., 1918.)—Describes wave-length measurements, in international units, of the ultra-violet spark spectra of the following metals: Ag, Al, As, Au, Ba, Bi, C, Ca, Cd, Cu, Pb, Sb, Sn, Sr, Tl, Zn. Wave-length tables are given. A. W.

77. *Crossed Spectra obtained by Combinations of Different Interferometers.* H. Nagaoka and T. Takamine. (Mathematico-Physical Soc., Tōkyō, Proc. 7, pp. 141-150, Oct., 1918. Phil. Mag. 27, pp. 126-136, Jan., 1914.)—The method of crossed spectra introduced by Kundt was utilised by Gehrcke and v. Baeyer for discriminating "ghosts" by means of interference points produced by Lummer-Gehrcke plates placed at right angles to each other. This method can be applied to combinations of different interferometers, and the crossed spectra thus obtained may sometimes be utilised for the purpose of accurately determining differences of wave-lengths. The following combinations were tried: (i) a plane grating crossed with an echelon, (ii) an

echelon with another echelon, (iii) a Lummer-Gehrcke plate with a Fabry-Perot air plate, (iv) Fabry-Perot air plate with an echelon, and (v) an echelon with a Lummer-Gehrcke plate. The first way of crossing was not effective on account of the low resolving power of the grating; the second, though somewhat better, was not at all comparable with the advantages that can be gained by the last three methods of combination. These last three are discussed in detail, reference being made to the structure of certain mercury lines. A. W.

78. Arc and Spark Spectra of Aluminium. R. Grünter. (*Zeitschr. wiss. Phot.* 18. 1. pp. 1-19, Nov., 1918.)—After a brief review of previous work on the spectrum of aluminium a detailed account is given of measurements of wave-lengths, in international units, in both the arc and spark spectra of the metal. The results are discussed with reference to Deslandres' laws. A table is also given of the wave-lengths of a number of bands, the results of Exner and Haschek, and those of Hasselberg being given for comparison. A. W.

79. Arc Spectra of Certain Metals below $\lambda=8200$. W. Huppers. (*Zeitschr. wiss. Phot.* 18. 2. pp. 46-88, Nov., 1918.)—A quartz spectrograph was employed and lines of wave-lengths below $\lambda 8200$ were re-measured in the spectra of Zn, Pb, Ca, Tl, Cd, Mg, Al, Cu, Ag, Li. Hartmann's formula was used for determining the wave-lengths of the lines. A large number of hitherto unknown lines were measured. Of these new lines some can be interpreted as series or combination lines. There is still, however, some uncertainty about the series lines of Ag and Cu. A. W.

80. Wave-lengths of Iron Spectrum Lines. K. Burns. (*Lick Observatory Bull.* No. 288. *Nature*, 92. p. 144, Oct. 2, 1918. Abstract.)—A series of determinations have been made at Marseilles, in the laboratory of Buisson and Fabry, of the standard iron spectrum lines between $\lambda 5484$ and $\lambda 8824$. Attention is drawn to the varying wave-lengths of arc lines depending on the location, in the arc, of the part examined by the spectrograph. C. P. B.

81. Pressure-shift of Iron Lines. H. G. Gale and W. S. Adams. (*Astrophys. Journ.* 87. pp. 891-894, June, 1918.)—In the course of a former investigation [Abstract No. 491 (1912)] it was found that for a pressure of 8 atmos. most of the lines could be classified into groups according to the amount of their pressure-shifts. The present work gives the results of examining the pressure-shifts of the lines which become very diffuse at high pressures, including the new group found by St. John and Ware in 1912 [Abstract No. 1699 (1912)]. The spectra were obtained at pressures varying from 5 or 10 cm. to 1 or 2 atmos., so that the lines should be more easily measurable. Observations have been made on about 180 lines in the region between $\lambda 4900$ and $\lambda 5700$, and a table is given showing the detailed results, including the lines exhibiting shift to the violet with increasing pressures. C. P. B.

82. Behaviour of Spectrum Lines with Satellites in a Magnetic Field. W. Voigt. (*Ann. d. Physik*, 42. 4. pp. 815-824, Nov. 4, 1918.)—A mathematical treatment based on the electron theory of absorption and dispersion. A. W.

83. Anomalous Effect with X-rays. F. R. Gorton. (*Science*, 88. pp. 547-548, Oct. 17, 1918.)—A sensitive plate is placed film downwards on a silver coin, and a second silver coin so placed above the plate that areas of contact

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of the plate and coins partially overlap; the plate and coins are enclosed in a light-tight box and exposed to X-rays from above. When the plate is developed the result is, of course, a light area with but little effect due to radiation transmitted by the upper coin and a dark area due to secondary radiations from the coin below. The anomaly appears at the area of overlapping coins. Since this receives its impression both from the transmitted rays and from the secondary rays from the coin below, it is to be expected that this area will be darker than the remaining area shaded by the upper coin. The opposite is found to be true. With small plates of Pb the effect is reversed, although Au and Cu give the same effect. E. M.

84. Absorption of Characteristic X-rays by Gases and Vapours. R. C. Gowdy. (*Journ. de Physique*, 8. Ser. 5. pp. 622-629, Aug., 1918.)—The rays from an X-ray-bulb were allowed to fall on a radiator, and the characteristic radiation emitted was measured after passage through a long chamber which could be evacuated or filled with the gas under observation. Tables are given of the absorption coefficients of the radiations of Fe, Ni, Cu, Zn, and As in Au, O₂, N₂, CO₂, H₂, H₂S, C₂H₂, CS₂, C₄H₁₀O, (CH₃)₂CO, CHCl₃, C₂H₅I, C₂H₅Br, and Al. The coefficients of absorption of any two radiations were found to be approximately in the same ratio for any of the gases examined. With regard to As and Zn, however, for gases containing elements of higher atomic weight than 27, the Zn radiation has the larger coefficient of absorption, while for the other gases the reverse holds. This result appears to show that As emits a soft radiation capable of exciting characteristic rays in elements of atomic weight less than that of Al. E. M.

85. Transmission of X-rays through Fibrous, Lamellar, and Granular Substances. S. Nishikawa and S. Ono. (*Mathematico-Physical Soc., Tōkyō, Proc.* 7. pp. 181-188, Sept., 1918.)—With the usual Friedrich and Knipping arrangement the photographs obtained with fibrous asbestos placed normal to the X-ray beam show a set of nearly straight bands passing through the central spot. Of these bands the one in a direction perpendicular to the axes of the fibres is especially conspicuous. If the plane of the asbestos is inclined to the normal, the symmetry of the figure with respect to the principal band is lost. The phenomena can be satisfactorily explained on the assumption that the specimen consists of a number of elementary crystals of a definite prismatic structure arranged parallel to the fibre, and otherwise quite indefinitely, and that each face of elementary crystals gives rise to reflection when a beam of X-rays falls upon it. Organic fibres such as silk, wood, bamboo, show the same effects, although negative results were obtained with quartz fibres and glass wool. Lamellar substances such as talc and mica gave a series of bands radiating from the central spot. With granular substances such as marble, fine powders of rock-salt, quartz, carborundum, etc., photographs were obtained in which the central spot is surrounded by innumerable small spots of which the intensity is a maximum at a certain distance from the centre. In experiments with rolled and annealed metal-foils results were obtained similar to those of Keene [Abstract No. 1965 (1918)]. E. M.

86. Reflection of X-rays by Crystals. II. W. H. Bragg. (*Roy. Soc., Proc. Ser. A.* 89. pp. 246-248, Sept. 22, 1918.)—In a previous paper by the author and W. L. Bragg it was shown that the wave-length of a homogeneous beam of X-rays can be found accurately in terms of the spacing of the
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elements of a crystal [Abstract No. 1880 (1918)]. From more recent work [see next Abstract], it appears that reflection phenomena lead to definite knowledge of crystal structure, and various quantitative determinations may now be completed. The elementary volume in rock-salt is a cube with 1 atom of Na at each of four corners, with 1 atom of Cl at each of the other four. In other words, the number of elementary volumes in any space of measurable dimensions is equal to the number of atoms in that space. Assuming the mass of a hydrogen atom to be 1.64×10^{-24} and the density of rock-salt 2.15, the number of atoms or elementary cubes per cm.³ is calculated to be 4.48×10^{23} . The edge of the cube is thus 2.81×10^{-8} cm., and this is thus the distance between consecutive reflecting planes parallel to (1.0.0). The principal bundle of X-rays from a Pt antikathode is found to be a doublet with two sets whose wave-lengths differ from each other by less than 2 per cent. of either. The average glancing angle of reflection is 11.8° . This gives a wave-length

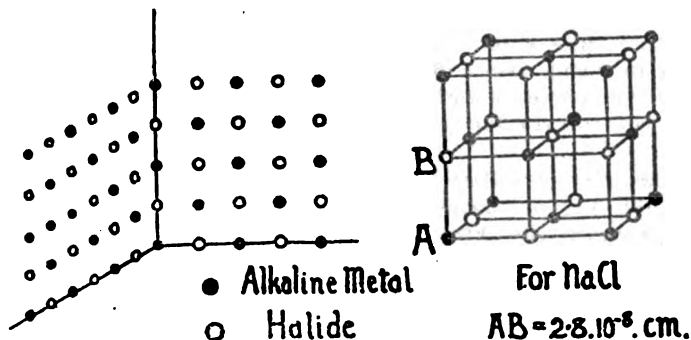
$$= (2d \sin \theta) = 2 \times 2.81 \times 10^{-8} \times 0.196 = 1.10 \times 10^{-8}.$$

A bulb having a Ni antikathode gives one weak beam of homogeneous rays reflected at a glancing angle of 17.2° ; the corresponding wave-length is 1.66×10^{-8} . A tungsten antikathode gives a beam at an angle of 12.9° , and the wave-length is therefore 1.25×10^{-8} . On the basis of existing theories certain numerical relations might be expected to subsist between these quantities. In the first place, the "quantum" energy for a wave-length 1.10×10^{-8} is $h\nu = 1.78 \times 10^{-8}$ erg. From Whiddington's results the energy of the kathode ray required to excite the X-ray of the L series in Pt is 2.14×10^{-8} erg. These numbers are in very satisfactory agreement, and it is also shown that the absorption coefficient of the radiation in question is almost exactly that of the excited L radiation in Pt. A comparison of the different metals examined shows, further, that the frequency of the radiation is very nearly proportional to the energy of the kathode ray required for its excitation.

E. M.

87. Structure of Some Crystals as indicated by their Diffraction of X-rays. W. L. Bragg. (Roy. Soc., Proc. Ser. A. 89. pp. 248-277, Sept. 22, 1918.)—The author advances two methods by which X-rays may be made to help to a determination of crystal structure. The first is based on the Laue photograph and implies the reference of each spot on the photograph to its proper reflecting plane within the crystal. It then yields information as to the positions of these planes and the relative number of atoms which they contain. Thus the more important planes of the crystal system are those densely packed with points of its space lattice, and from this fact it follows that these planes contain rows along which the points are closely packed. The author compares the patterns obtained by passing X-rays through NaCl, KCl, KBr, and KI. For KCl the patterns are simple, having spots of nearly equal intensity, while KBr and KI give modified patterns. If the molecules in each case were at the points of the space lattice, then, as the crystals are similar, the patterns ought to be the same for each substance. Assuming, however, that the atoms are placed at the points of the lattice and that the weight of an atom in the main defines its effectiveness as a diffracting centre, the results are simply explained. In the case of KCl the atoms of K and Cl have nearly the same weight; hence the simple pattern. In the case of KBr and KI the whole diffraction will practically be due to the heavy Br

and I atoms. Thus the effective "planes" in which the X-rays producing the spots are reflected will be different for KBr and KI to those for KCl. The author shows that the results can be quantitatively explained in this way, and thus the following structure is obtained.



The results are verified and extended to other crystals by measuring the glancing angle at which one of the homogeneous beams of X-rays from a Pt kathode is reflected from various faces of a crystal. It has previously been shown that from these measurements the distance d between successive reflecting planes can be obtained [$n\lambda = 2d \sin \theta$; Abstract No. 1158 (1918)]. From this the positions of the heavier atoms can be estimated. Further evidence is thrown upon the crystal structure by the results of the relative intensities of the reflected beams of homogeneous radiation in the different orders, this evidence giving the positions of the lighter atoms. E. M.

88. *X-ray Interference Maxima.* G. Wulff and N. Uspenski. (Phys. Zeitschr. 14. pp. 788-785, Aug. 15, 1918.)—Some observers have found a striation of the interference maxima obtained by grazing reflection from a crystal face, and have been inclined to regard these striations as spectrum lines or interference spectra of different orders. They are, however, open to a simple explanation. They are produced by slight faults in the flatness of the crystalline cleavage plane used. The individual crystals are slightly inclined to each other, and the striation may show a very varying aspect, but all the striæ must lie on ellipses having a common vertex on the primary beam. The order of magnitude assigned to X-rays by M. Laue cannot be controverted by arguments based on these striations. E. E. F.

89. *Interference of X-rays.* G. Wulff and N. Uspenski. (Phys. Zeitschr. 14. pp. 785-787, Aug. 15, 1918.)—It was shown by G. Wulff [Abstract No. 1157 (1918)] that the X-ray interference maxima may contain an harmonic series of waves, half whose fundamental length equals the projection of the thickness of layer of the space lattice upon the direction of the primary beam. This is confirmed by observations on further reflections of these maxima by means of a second crystal. E. E. F.

90. *Three-fold Symmetry of Röntgen-ray Photographs from Regular Crystals.* M. Laue. (Ann. d. Physik, 42. 2. pp. 897-414, Sept. 28, 1918.)—Instead of the four-fold symmetry previously worked out theoretically and with which certain photographs of the interference phenomena agreed, the author now
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follows out mathematically the theory of a three-fold (*dreizählig*) symmetry of these phenomena. He is thus led to the conclusion that the points in the photographs are not all due to commensurate wave-lengths, but that a certain spectral law holds. In one such analysis of the experimental results the following wave-lengths are found:— 2.02×10^{-9} , 8.24×10^{-9} , 8.64×10^{-9} , 4.85×10^{-9} , 5.68×10^{-9} , 7.88×10^{-9} , 8.09×10^{-9} , 8.90×10^{-9} , 1.21×10^{-8} , 1.58×10^{-8} , 2.80×10^{-8} (all multiples of $4.75 \times 10^{-9} \times 8.50 \times 10^{-9} = 4.04 \times 10^{-10}$ cm.), also 8.76×10^{-9} , 4.18×10^{-9} , 6.28×10^{-9} , 1.00×10^{-8} , 1.88×10^{-8} (multiples of $4.92 \times 10^{-9} \times 8.50 \times 10^{-9} = 4.18 \times 10^{-10}$ cm.) [See Abstract No. 1158 (1918)]. (Author's *Corrigendum*, *Ibid.* p. 1592). E. H. B.

91. Scattering of α -Particles. F. Mayer. (*Ann. d. Physik*, 41. 5. pp. 981-970, Aug. 5, 1918.)—The author has repeated the experiments of Geiger [Abstracts Nos. 1248 (1910), 698 (1912)] on the "small" scattering of α -particles. A polonium source was used with a slit to form a pencil of α -particles, the latter being observed in a zinc sulphide screen placed beyond the slit. The distribution of scintillations when foils of various materials were placed between the slit and screen was observed, and the mean angle of scattering deduced. The results were found to be in agreement with those of Geiger, and by substituting in Rutherford's formula for compound scattering [Abstract No. 1847 (1911)] the number of electrons in the atom is calculated to be between the atomic weight and half the atomic weight. Observations of the scattered α -particles were also obtained by counting the "grains" on a photographic plate rendered capable of development [see Abstract No. 922 (1910)]. The variation of scattering by a given foil between ordinary temperature and about 400° C. was also investigated, but no change could be observed. E. M.

92. Magnetic Deflection of Rubidium Rays. K. Bergwitz. (*Phys. Zeitschr.* 14. pp. 655-658, July 15, 1918.)—Shows that rubidium rays are β -rays of velocity about 1.8×10^{10} cm./sec. This agrees with the failure to trace an α -radiation by scintillation or heat effects (Büchner, Henriot). E. E. F.

93. Scattering of Particles of Matter with β -Rays. M. Levitska. (*Russian Physico-Chemical Soc., Journ.* 44. 8. pp. 81-97, 1912.)—Rutherford's conclusion is that Crowther's determination of ϕ/\sqrt{i} enables a correct calculation of N_e to be made as follows:—

Element.	Weight of Atoms.	N.
Aluminium	27	22
Copper	63.2	42
Silver	108	78
Platinum	194	188

The numbers of electrons are, however, altogether different to those given by Thomson, while Wilson's differ from both. This problem of scattering cannot, therefore, as yet be considered as satisfactorily solved. I. P.

94. Analysis of the γ -Rays from Radium D and Radium E. E. Rutherford and H. Richardson. (*Phil. Mag.* 26. pp. 824-832, Aug., 1918.) VOL. XVII.—A.—1914.

—In a previous paper [Abstract No. 1675 (1913)] the authors have given results of the analysis of the γ -radiation from RaB and RaC. In the present paper the γ -radiation from RaD and RaE has been examined by a similar method. These radio-active substances are of unusual interest in considering the problem of the connection between β - and γ -rays, since the γ -rays emitted by RaD and RaE together are exceedingly feeble in intensity compared with the β -rays. Ra(D + E + F) was taken, and the RaF separated by dipping a Cu plate into the solution. The RaE was then separated by dipping in a Ni plate, and by further operations the D and E were separately isolated on filter paper without impurities of high atomic weight, so that no excited radiations should disturb the measurements. The results showed that the transformation of each atom of RaD is accompanied, on the average, by 50 times the amount of γ -radiation from the transformation of an atom of RaE. The absorption results, combined with those obtained in a previous paper for RaB and RaC, are given in the following table :—

	Absorption Coefficient μ in Aluminium.	Mass Absorption Coefficient μ/D in Aluminium.
RaB	$\left\{ \begin{array}{l} 280 \text{ (cm.)}^{-1} \\ 40 \text{ " } \\ 0.51 \text{ " } \end{array} \right.$	$\left\{ \begin{array}{l} 85 \text{ (cm.)}^{-1} \\ 14.7 \text{ " } \\ 0.188 \text{ " } \end{array} \right.$
RaC	$\left\{ \begin{array}{l} 0.115 \text{ " } \\ 45 \text{ " } \end{array} \right.$	$\left\{ \begin{array}{l} 0.0424 \text{ " } \\ 16.5 \text{ " } \end{array} \right.$
RaD	$\left\{ \begin{array}{l} 0.99 \text{ " } \end{array} \right.$	$\left\{ \begin{array}{l} 0.86 \text{ " } \end{array} \right.$
RaE	Nearly the same types of radiation as from RaD, but relatively very feeble.	

The soft type of radiation $\mu=45$ from RaD and RaE corresponds to the characteristic X radiation of series L from an element of at. wt. 210, i.e. the atomic weight calculated on the disintegration theory. E. M.

95. Radium D and the Final Product of the Radium Disintegration Series. R. Whytlaw-Gray. (Nature, 91. pp. 659-660, Aug. 28, 1918.)—The author has made experiments on the chemical nature of the active deposit of Ra in tubes which four years ago contained about 0.2 curie of RaEm. Thus the material consisted of about 1/1000 mgm. of a mixture of RaD with about 15 per cent. of RaG (the end product). The substance appeared as a grey submetallic deposit which on gently warming in an atmosphere of chlorine changed to a pure white, apparently homogeneous crystalline chloride. On heating *in vacuo* to 220° C. none of the material was evaporated. The chloride was dissolved in water and tested for lead by Behren's method, viz., by the formation of a characteristically crystalline triple nitrite with the nitrites of copper and potassium. The results showed that it is probable that both RaD and RaG form the triple nitrite identical with that formed by lead. Thus the investigation tends to support the theories of Soddy, Russell, and Fajans, that elements can exist chemically identical but differing from one another by a few units in atomic weight. E. M.

96. Radiation of Radium at the Temperature of Liquid Hydrogen. Mme. P. Curie and H. Kamerlingh Onnes. (Konink. Akad. Wetensch. VOL. XVII.—A.—1914, D

the discrepancy between Svedberg on one hand and H. A. Lorentz, Smoluchowski, Langevin, and v. Schweidler on the other [Abstract No. 1218 (1913)].
E. E. F.

99. *Disintegration of Uranium X*. A. Fleck. (Phil. Mag. 26. pp. 528-535, Sept., 1918.)—The theoretical considerations regarding the evolution of the radio-elements through the periodic law put forward by various authors suggested that a then unknown β -ray product should exist between Ur and Io. Fajans and Göhring have announced the discovery of such a body, and in the present experiment this result is experimentally verified. A UrX solution is taken, and a lead plate immersed. It is found that the lead plate takes out of the solution a rapidly decaying product. Further investigation showed that this product can be partly isolated by precipitating bismuth oxychloride or lead chloride in a UrX solution, the new product being associated with the precipitate in each case. UrX therefore consists of two products, UrX₁ and UrX₂, the half-time periods being 24.6 days and 1.1 mins. respectively. The experiments further confirm Fajans and Göhring's result that the hard β -rays of UrX come from UrX₂, and the soft ones from UrX₁. The results also suggest that UrX₂ cannot be the parent of actinium.
E. M.

100. *Branch Product in Actinium C*. E. Marsden and R. H. Wilson. (Nature, 92, p. 29, Sept. 11, 1918.)—It is now well established that the atoms of RaC and ThC can break up in two distinct ways, i.e. with the expulsion of either an α - or a β -particle. It is to be expected from the close analogy between the C products of the various radio-active families that AcC should also show abnormal disintegration, and, further, it might be anticipated that one of the branch products would emit an α -particle with great velocity and corresponding long range. The present experiments were made to test this point. A source of actinium active deposit was covered with a sheet of mica equivalent to about 5 cm. air, in stopping power of α -particles, and the whole placed in an exhausted chamber with a zinc sulphide screen about 2 cm. from the source. The numbers of scintillations appearing on the screen per min. for different pressures of the air inside the apparatus were counted, and thus the falling-off of the α -particles with "range" determined. The results showed that in addition to the α -particles of AcC with range 5.4 cm. a small number, about 1 in 600, can penetrate as far as about 6.45 cm. Special experiments showed that the long-range α -particles could not be due to radium or thorium impurity, and they must therefore be attributed to the expected new branch product.
E. M.

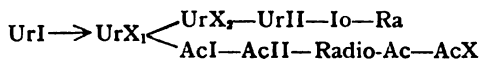
101. *Distribution of the Active Deposit of Actinium in Electric Fields*. H. P. Walmsley. (Phil. Mag. 26. pp. 381-401, Sept., 1918.)—It is now generally accepted that the active deposits of Th and Ra carry positive charges, and are in consequence concentrated on the cathode in electric fields. Some doubt, however, has arisen in the case of Ac [Abstracts No. 2067 (1909), etc.]. The author first shows that in this type of experiment it is necessary to introduce "pure" emanation into the electric fields employed, i.e. emanation free from dust and active deposit. If any changes occur at all in the electrification of the active deposit, it is necessary to eliminate "old" deposit before employing electric fields. On this account it is undesirable to allow the emanation to diffuse directly from the actinium preparation into the field. These conditions apply particularly in the case of actinium emanation, as, owing to its quick disintegration (period 89 secs.), active deposit
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atoms are soon associated with it. In the present experiments the emanation was blown into the ionisation chamber through a tube having its end filled with cotton-wool to remove the active deposit particles. In this way it was shown that all the atoms of both AcA and AcB acquire a positive charge in the moment of their creation. As regards their electrical properties, both AcA and AcB behave exactly like the positive ions produced by their radiations. They recombine in exactly the same way, and the activity collected by the anode in an electric field is due solely to deposit atoms which have recombined. Under favourable circumstances recombination continues until the whole of the active deposit is electrically neutral. E. M.

102. *Uranium Y*.—G. N. Antonoff. (Acad. Sci. St. Pétersbourg, Bull. 15. pp. 875–878, Nov. 1, 1918.)—In a previous paper [Abstract No. 1684 (1911)] the author described the separation of a product, UrY, which was presumed to be a small lateral disintegration product from Ur. Later Fleck questioned the existence of this product, and presumed that the anomalous results were due to thorium impurity. The present author has now repeated his experiments with purified uranium supplied by Soddy, and similar to that used by Fleck. The existence of UrY is reaffirmed, its activity being stated to be at least 2% of that of UrX. This activity is of the order of that required if UrY is the parent of the actinium family. E. M.

103. *Uranium X₁*.—O. Hahn and L. Meitner. (Phys. Zeitschr. 14. pp. 758–759, Aug. 15, 1918.)—The authors confirm the existence of UrX₁, discovered by Fagans and Göhring, and describe a simple method of isolating it. UrX₁, the parent of UrX₂, has the properties of thorium, whereas UrX₂ is allied to tantalum. The separation of the two products is therefore the same as that of the separation of Th and Ta. UrX solutions are heated with tantalum pentoxide and filtered. To reduce the adsorption of UrX by the Ta compounds, a small quantity of thorium nitrate is added. The half-period of UrX₁ is 1.17 mins. E. E. F.

104. *Complexity of Radio-Actinium*. O. Hahn and L. Meitner. (Phys. Zeitschr. 14. pp. 752–758, Aug. 15, 1918.)—Geiger's relation between the life-period of a radio-active substance and the range of its α -particles would indicate that radio-actinium consists of two bodies, one of half-period 19.5 days, giving β -rays, and one of half-period 1.5 days, giving α -rays. The authors study this question by means of the curves of increasing α - and β -radiation, and conclude that there is no evidence whatever for the second product. They put forward the following scheme to show the derivation of actinium—



Of these, UrX₁, UrX₂, Radio-Ac, and possibly Ac2 emit β -rays, and Radio-Ac also emits α -rays. A difficulty lies in the formation of bivalent AcX from quadrivalent Radio-Ac, if α - and β -rays are emitted simultaneously, but similar difficulties are presented by Ra, ThX, and other products. E. E. F.

HEAT.

105. Measurement of Specific Heats. F. A. Lindemann and F. Schwes. (Phys. Zeitschr. 14. pp. 766-767, Aug. 15, 1918.)—Instead of calculating the heat supplied from the Joulean heating of a wire and the temperature from the temperature coefficient of resistance [Nernst and Eucken, Abstract No. 1714 (1909)], the authors propose to measure the temperature by inserting the substance direct into the bulb of a hydrogen thermometer. The method is described in detail, and applied to the specific heat of KCl. It is, however, of limited range of application, since powdered substances adsorb hydrogen in considerable quantity. It can be applied to metals and coarse-grained substances, and may be useful in measuring specific heats, say, at the temperature of liquid helium. E. E. F.

106. Thermo-calorimetric Investigations on Platinum at High Temperatures. O. M. Corbino. (N. Cimento, 5. Ser. 6, pp. 313-328, May, 1918.)—A modification of the method previously described [see Abstracts Nos. 1063, 1064 (1912)] is applied to the investigation of the specific heat of Pt. The specific heat at constant volume is found to have the following values in arbitrary units at the given temperatures ($^{\circ}$ C.): 510° , 215; 740° , 219; 956° , 225; 1210° , 233; and 1525° , 244. The specific heat at constant volume hence rises almost linearly with the temperature. According to White's measurements [compare Koenigsberger, Abstract No. 878 (1912)], at 500° the value of the atomic heat is 6.47, on which basis its value at 1500° is 7.87. This result confirms the conclusion drawn from the measurements made with tungsten (*loc. cit.*), that with metals the atomic heat greatly exceeds the theoretical value. The author had hoped to make use of the relation between the specific heat and the variation of resistance with the temperature in order to measure high temperatures, but the inconstancy of the specific heat renders this impracticable. T. H. P.

107. Evaporation Temperature of Carbon in the Arc Lamp. O. Lummer. (Journ. f. Gasbeleuchtung, July 12, 1918. Abstract of paper read before the German Illuminating Engin. Soc. Electrical World, 62. p. 296, Aug. 9, 1918.)—If the carbon in the arc lamp has a temperature of evaporation the temperature of the carbon must be independent of the arc length and of the current, but must change with the atmospheric pressure as does the evaporation temperature of any substance. From tests made by the author it appears that the temperature is independent of the current. Further, the temperature of the positive crater decreases from 4000° abs. to 3800° if the pressure is reduced from 1 atmo. to 0.25 atmo. This indicates that the atmosphere of the crater is the boiling temperature of carbon. The tests are to be repeated and extended to 80 atmos. The negative crater has in general a lower temperature than the positive crater. The positive crater seems to begin to boil at temperatures below atmospheric. J. J. S.

108. Vapour Pressures of Hydrogen from the Boiling-point down to near the Triple Point. H. Kamerlingh Onnes and W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 440-445, Nov. 27, 1918. ComVOL. XVII.—A.—1914.

munication No. 187*d* from the Phys. Lab., Leiden.)—The value found for the heat of vaporisation of hydrogen at the boiling-point differs appreciably from those calculated by means of the Clausius-Clapeyron formula from the vapour pressures of hydrogen between the boiling-point and the triple point as determined by Dewar [Abstract No. 1757 (1905)] and by Travers, Senter, and Jaquerod [Abstract No. 1025 (1903)]. The authors have therefore made fresh measurements of the vapour pressure of hydrogen in this region, making use of an apparatus similar to that described by Onnes and Braak (*Ibid.* May, 1908). The results obtained show that the curve representing $\log p$ as a function of $1/T$ is slightly concave upwards, whereas Travers and Jaquerod's numbers give a curve slightly convex upwards. The Wrede-Rankine-Keesom formula, $\log p = 4.6068 - 58.40/T + 61/T^2$, gives values of p differing but little from the observed numbers, and gives for the boiling-point the value 20.83° K. or -252.76° C. The heat of vaporisation of hydrogen at 75.15 cm. is calculated to be 105.5 cal. , which is smaller than that found by direct measurement at the lowest velocity of evaporation, namely, 110.2 . This result perhaps indicates insufficient care to prevent condensation of the vaporised hydrogen in the calorimeter. Indeed, when the velocity of vaporisation was doubled, smaller values were obtained: 108.5 and 109.8 at pressures of 76.1 and 77.75 cm. respectively.

T. H. P.

109. *Equilibrium-diagram of Water.* G. Tammann. (*Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse*, 1. pp. 99–136, 1918.)—The author calls attention to the fact that if light ice is converted partially by pressure into dense ice, the pressure-temperature curve of equilibrium differs according as the dense ice was prepared above -80° or between -70° and -80° . These curves are most conveniently followed by recording the equilibrium pressures as the temperature is varied. The remarkable fact is that these two curves intersect one another, but without giving the usual properties of a triple point. The existence of an equilibrium-curve (nearly parallel to the axis of pressure) between dense Ice II and dense Ice III is confirmed, but this does not account completely for the phenomena in question. The existence of a new variety of Ice III, more stable than the former one (now called Ice III'), is recorded; it is prepared from water at -85° and 2900 kg./cm.^2 , whereas the other form is prepared from Ice II by warming up from -70° ; being the more stable form it melts at a higher temperature, -15.9° (corr. -17.4) instead of -18.4° (corr. -19.9) at 2513 kg./cm.^2 pressure. Ice III' can be prepared by compressing water to 2800 kg./cm.^2 and cooling slowly. If the volume is increased at a temperature above -80° a partial conversion to light ice takes place, but the equilibrium curve differs from that for Ice I and Ice III', and is attributed to the formation of a new light Ice I'. The melting-point curve for Ice I' lies below that of ordinary Ice I — about 0.5° lower at 500 kg./cm.^2 and diminishing to 0.15° lower at 2100 kg./cm.^2 . The existence of two other uncommon forms of light ice is indicated: these are referred to provisionally as Ice I'' and Ice I'''. Ice I' is possibly identical with the Ice IV of a previous paper, but the hint is given that there may be not less than seven forms of light ice, in addition to some five forms of dense ice. The author proposes to classify them in groups; the members of each group are found to cover much the same area in the $p.T$ diagram and are thought to contain identical molecules, whereas the groups themselves, I, II, III, V, VI, may represent different molecular structures.

T. M. L.

110. *Radiation.* J. E. Ives. (*Journ. Acad. Nat. Sciences, Philadelphia*, 25. pp. 849–862, March, 1912.)—A discussion of the ether and radiation, VOL. XVII.—A.—1914.

involving the relativity principle and the quantum hypothesis, the chief conclusions of which may be stated as follows :—(1) Energy has no real existence independently of matter, and cannot exist free in space. (2) The types of electrical oscillators are very numerous, and it is improbable that the Hertz oscillator can be considered the sole elementary type. (3) The so-called velocity of light is not a quantity of the nature of a mechanical velocity. Its reciprocal may, perhaps, be regarded as of the nature of a time reaction constant. (4) Planck's energy-quantum hypothesis is a statistical hypothesis, and probably only true for the short waves of heat and light, and not for long electric waves. (5) Einstein's hypothesis of the light-quantum is untenable because it is based on the assumption that energy can exist free in space.

E. H. B.

111. *Black-body and True Temperatures for Tungsten, Tantalum, Molybdenum, and Carbon.* C. E. Mendenhall and W. E. Forsythe. (Astrophys. Journ. 87. pp. 880-890, June, 1918.)—The increasing use of various electrically-heated metallic filaments in a variety of physical experiments, together with the difficulty of determining the true temperature of such filaments, suggested the desirability of securing data for finding the true temperature of the radiating surface from the more readily observed optical black-body temperature. Details of the method have already been published [see Abstract No. 770 (1911)]. The results are given in graphical form, indicating in most cases a slight curvature of the TS-curve, especially for the lower range of temperatures. In the case of molybdenum the relation is linear from 1500° up, and for tungsten from 1000° to 8000°. It is concluded that the optical absorbing power of these four substances varies with temperature instead of being constant as hitherto considered.

C. P. B.

112. *Melting-point of Molybdenum.* C. E. Mendenhall and W. E. Forsythe. (Astrophys. Journ. 88. pp. 196-198, Sept., 1918.)—A direct determination of the melting-point of molybdenum by the V-method [see preceding Abstract], gives the value of the true melting-point as 2585° C., and the black-body melting-point, 2287° C. for $\lambda = 0.658 \mu$. These temperatures are on basis of $C_p = 14,500$, and palladium melting-point 1549° C. Comparisons are given with results of other workers.

C. P. B.

113. *Deduction of Planck's Law of the Distribution of Energy from the Agglomeration Hypothesis.* C. Benedicks. (Ann. d. Physik, 42. 1. pp. 188-162, Aug. 28, 1918.)—The full paper corresponding to Abstract No. 1458 (1918).

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

114. *Free Electrons in Non-magnetic Metals.* T. Otashiro. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 118-123, July, 1918.)—From the experimental results as to the Hall-effect and the electric current, it is here calculated that the number of free corpuscles per cm.³ of non-magnetic metals lies between 10^{22} and 10^{23} .
E. H. B.

115. *Electromagnetic Induction.* S. J. Barnett. (Phys. Rev. 2. Ser. 2. pp. 828-826, Oct., 1918.)—The author here defends and maintains his criticism of the work on unipolar induction by E. H. Kennard. [See Abstracts Nos. 210 and 1179 (1918).] It is here pointed out that there is no justification for the assumption made by Kennard that $\text{div } \mathbf{E} = 0$. In conclusion, the author considers briefly what happens on the theories of Hertz, Einstein, and Lorentz, in each of the two principal experiments involved in the discussion of relative motion. The case in which the condenser rotates will be called Case I., that in which the condenser remains at rest as Case II.

On the theory of Hertz, the condenser is uncharged in Case I. and also in Case II. On Einstein's theory the condenser is charged (as indicated in the present paper) in Case I., and also in Case II. On the theory of Lorentz the condenser is charged (as in this paper) in Case I., and is uncharged in Case II. Lorentz's theory is thus the only one which is consistent with both sets of experiments.
E. H. B.

116. *Elementary Electric Charge and Avogadro's Constant.* R. A. Millikan. (Phys. Rev. 2. Ser. 2. pp. 109-148, Aug., 1918. Phys. Zeitschr. 14. pp. 796-812, Sept. 1, 1918.)—The errors involved in the determination of the electronic charge by the oil-drop method [Abstract No. 943 (1911)] affect the density of oil and air, the electrostatic field, the viscosity of air the velocities of fall under gravitation and rise in the electrostatic field, the radius of the drop, and the correction necessitated by the failure of Stokes' law when the diam. of the drop is of the same order of magnitude as the mean free path of a gaseous molecule. After discussing these sources of error at considerable length, the author arrives at the following final values:—

Electronic charge $e = 4.774 \pm 0.009 \times 10^{-10}$.

Molecules in a gr.-molecule $N = 6.062 \pm 0.012 \times 10^{23}$.

Gaseous molecules in 1 cm.³ at N.T.P. $n = 2.705 \pm 0.005 \times 10^{19}$.

Molecular kinetic energy at 0° C. $E = 5.621 \pm 0.010 \times 10^{-4}$.

Constant of molecular energy $\epsilon = 2.058 \pm 0.004 \times 10^{-16}$.

Constant of entropy equation $k = 1.872 \pm 0.002 \times 10^{-16}$.

Action constant $h = 6.621 \pm 0.025 \times 10^{-27}$.

Constant of Wien's displacement law $C_2 = 1.4470 \pm 0.0080$.

E. E. F.

117. *International Agreement on Potential and Elasticity.* A. Korn. (Elektrotechnik u. Maschinenbau, 81. pp. 861-864, Oct. 12, 1918. Paper read VOL. XVII.—A.—1914.

before the 85. Naturforscherversamml., Vienna. *Phys. Zeitschr.* 15. pp. 1105-1109, Nov. 15, 1918.)—Describes in general terms the objects and methods of the proposed international conference on the possible agreement or standardisation of the more important conceptions and symbols in connection with the theories of potential and elasticity. E. H. B.

118. *Quaternion and Binary Forms of Minkowski's Electrodynamical Equations.* I. E. Waelisch. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 508-518, March, 1918.)—Mathematical. E. H. B.

119. *Vector Potential in Relation to Vector Angle.* F. Slate. (Phys. Rev. 2. Ser. 2. pp. 211-216, Sept., 1918.)—The author discusses the Vector Potential and gives various physical meanings to it, with the object of clearing up the mathematical haze in which it is enveloped. A. R.

120. *Rotatory Field Phenomena in Electrostatic Alternating Field.* E[mma] Becker. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 515-584, March, 1918.)—It had been supposed that the sense of the rotation of the field depended on the diam. of the body introduced in the alternating field, but it is here shown theoretically and experimentally that the thickness of the body has no influence on the sense of rotation. [See Abstracts Nos. 101 (1908) and 586 (1912).] E. H. B.

121. *Adsorption of Ions by Falling Drops, etc.* R. Lehnhardt. (Ann. d. Physik, 42. 1. pp. 45-66, Aug. 26, 1918. Extract from Dissertation, Berlin.)—A. Schmauss found [Abstract No. 460 (1908)] that water-drops falling through gases ionised by Röntgen rays adsorbed negative ions much more freely than positive. This was explained as being due to the higher mobility of the negative ions. R. Seeliger [Abstract No. 710 (1910)] working with continuous Röntgen radiation obtained a far smaller excess of negative ions adsorbed. Repeating Seeliger's experiments, but protecting the falling drops from Röntgen rays, the author obtains an intermediate ratio for uncharged droplets. The power of adsorption seemed to increase with the dielectric constant. With droplets equally and oppositely charged the number of adsorbed ions corresponds to the ratio of the mobilities of the ions attracted. Direct tests of the adsorbability of ions by falling steel balls showed ultimately that the adsorption is directly proportional to the mobility. Causes of divergence from this result are discussed. A. D.

122. *Calculation of the Capacity Coefficients for Two Unequal Spherical Electrodes.* A. Guillet and M. Aubert. (Journ. de Physique, 8. Ser. 5. pp. 718-724, Sept., 1918.)—The authors consider the case of two unequal spherical conductors external to one another. Using the method of images they get the series formulæ in terms of spherical functions analogous to those of Heine. No numerical examples are given. A. R.

DISCHARGE AND OSCILLATIONS.

123. *Field-canal Rays.* E. Wagner and J. Kutschewski. (Ann. d. Physik, 42. 8. pp. 665-672, Oct. 16, 1918.)—The name "Feldkanalstrahlen" is now applied to those canal rays moving towards the anode which are generated in an applied field. In the experiments they are differentiated from the

K_1 or retrograde rays and are also compared, as regards the Doppler-effect, with the primary canal rays under conditions of generation which are so far as possible similar. [See also Abstract No. 1474 (1918).] A. E. G.

124. *Helix of Wehnelt Kathode Rays used to Determine e/m and v .* J. B. Nathanson. (Phys. Rev. 2. Ser. 2. pp. 807-813, Oct., 1913.)—The helical path in the case of these rays was realised as follows. The rays were projected from a Wehnelt kathode in a direction perpendicular to the lines of force of a uniform magnetic field. The path assumed by the rays was a circle. Upon application of a uniform electrostatic field coinciding with the magnetic one, the circle was drawn out into the form of a helix. The values found are given in the table :—

Gauss. H.	Volts. V.	$(e/m) \times 10^{-7}$.	$v \times 10^{-9}$.
18.84	81.3	1.71	1.62
22.78	81.2	1.89	1.21
19.01	79.5	0.56	1.14
26.84	119.5	0.27	1.09
18.27	80.0	0.64	1.49
21.41	119.3	0.46	1.20
19.58	79.5	0.59	1.44
16.56	120.0	0.70	1.43
20.67	88.0	1.44	1.20
16.56	120.0	1.91	1.63
20.61	126.0	1.71	1.53
19.18	48.0	2.07	1.75
23.98	120.0	1.49	1.29
Mean.....		1.61	1.89

[See Abstract No. 556 (1912).]

E. H. B.

125. *The Cause of Emission of Electrons from Hot Kathodes.* A. Gehrts. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1047-1056, Oct. 30, 1913. Communication from the Physikal. Versuchsabteilung d. Accumulatoren-Fabrik A.G.)—While agreeing with the main points of the theory put forward by Fredenhagen the view is now expressed that the decomposition of the oxide is not occasioned by the current flowing from the anode to the kathode, but is produced essentially by thermic dissociation. In the experiments described on the chemical alteration of the oxide kathode by the passage of the current it is found that neutral calcium and oxygen atoms must be present in the oxide layer. Further experiments on the behaviour of oxide kathodes in different gases are being carried out. A. E. G.

126. *Monomolecular Ions in Gases, and New Method of Measuring Dimensions of Molecules.* W. Altberg. (Russian Physico-Chemical Soc., Journ. 44. No. 8. pp. 431-458, 1912.)—Gives first a review of P. Lenard's explanation of the formation of ions [Abstracts Nos. 650 (1903) and 2958 (1904)]. A. Becker [Abstract No. 1939 (1909)] has fully explained the case of small ions, and also has shown that the motion of ions depends on their growth [Abstract No. 66 (1912)]; but the case of more rapid ions has not till now

been determined by means of cylindrical condenser. The author made a few tests with the same gas but employing different gas velocities; the distance of the nets also changed. For the observations negative ions in CO_2 were used.

Density of Ions.—To ascertain if the position of point of intersection has any influence upon the density of ions the intensity of the Röntgen rays was weakened by means of an Al plate 0.5 mm. thick and both curves were kept under observation, first for the weakened rays and afterwards for the unweakened rays. The points of intersection, it was found, did not change, though the density of the ions was changed in proportion of 1 : 8.

Growth of Ions.—Change in distance of the measuring net from the X-rays, necessitates change in the time taken for the ions to reach the net; this brings about ions of different sizes, and to test this growth a large condenser with nettings placed at a distance of 7 cm. was used.

From observation of mobilities it is found, as shown in the table below, that the dimensions of ions are nearly equal to the calculated radius of the molecule. It is hence inferred that the most rapid ions observed with the help of the net condenser can be considered as being separate molecules.

Gas.	Air.	CO ₂ .	O ₂ .	N ₂ .	H ₂ .
Ohms defined in cm./ sec. ⁻¹ /volt cm. ⁻¹	7.5	5.7	7.6	7.0	(105)
	10.1	5.8	10.3	(9.5) ^b	(152)
Dimensions of ions, ν × 10 ⁹ cm.	21.5	19.2	20.8	22.9	(7.9)
	16.6	18.9	15.8	(17.6)	(4.7)

The question of mixed gases is also investigated.

I. P.

127. Photoelectric Properties and Contact Resistance of Thin Kathode Films. O. Stuhlmann, Jr., and K. T. Compton. (Phys. Rev. 2. Ser. 2. pp. 199-210, Sept., 1913).—The relation between the velocity of the electrons emitted by the action of light on metals and the frequency of the light has been deduced by Einstein on the unitary theory of light, and Richardson derived the same equation by thermodynamic and statistical methods which do not necessarily involve the unitary light hypothesis [Abstract No. 1414 (1912)]. Several investigators have succeeded in obtaining electric velocities considerably higher than those ordinarily obtained in photoelectric measurements. Most of these high velocities have been obtained when sparks were used as the source of light. These have been shown to be due to secondary action from electromagnetic radiation accompanying the spark discharge. O. v. Baeyer and Gehrtz, and more recently Dike and Brown have obtained high velocities in other ways. It becomes necessary to discover some error in the results or interpretation of the results given by Dike or to reject Richardson's theory. It seems probable that the great increase in the photoelectric potentials following an induction coil discharge may be due principally or entirely to a great increase in the contact p.d. Thus the initial kinetic energy with which the electrons leave the metal film may have the ordinary value predicted by Richardson's theory. After emission this velocity may be greatly increased by the expulsion due to an absorbed negative charge in the sputtered plate or due to their passage through a charged insulating layer, deposited on the

surface by the induction coil discharge. The present experiments are undertaken to test these explanations of apparent high velocities. As a result it is concluded that the high potentials observed by Dike and Brown must be ascribed to the presence of oil or grease, introduced while making the metal apparatus, to vacuum wax in the ground joints, or to some other material which could produce a charged layer. There is no evidence in these experiments to show that the photoelectric velocities should be different from those predicted by Richardson's theory. Saturation currents and contact resistances are also investigated. It is evidently a very difficult matter to make good electrical contact with very thin films. Patterson, when experimenting with the specific resistance of thin metal films found that for very thin Pt-films the specific resistance increased more rapidly than was predicted by the electron theory of conduction suggested by J. J. Thomson. It seems probable that all or part of this unpredicted increase may be due to high contact resistance superposed on the regular resistance of the film. If this is true it would explain the discrepancy between theory and experiment in the case of very thin films. A. E. G.

128. Relation between Photoelectric Currents and Light Intensity. J. Elster and H. Geitel. (Phys. Zeitschr. 14. pp. 741-752, Sept. 1, 1913.)—Discusses the various factors which may interfere with the proportionality of photoelectric discharge from a potassium or rubidium cell and the light intensity. The dark discharge and the dark after-effect are attributable to charges on the glass wall of the cell, and means of avoiding these are indicated. The photo current is then found for a wide range of illuminations, varying from $1/8$ of bright sunlight (about 30,000 lux) down to about 6×10^{-4} lux. On taking each of the sources in steps regulated by Nicol prisms, proportionality was found to hold good along the entire range. The lowest illumination reached was 2.4 microlux, which, with a voltage of 200, gave a current of 1.79×10^{-12} amp., as measured by an electrometer method. E. E. F.

129. Photoelectric Properties of Liquids. M. La Rosa and V. Cavallaro. (N. Cimento, 6. Ser. 6. pp. 39-47, July, 1918.)—Observing photoelectric discharges from liquids illuminated by a carbon arc or quartz mercury lamp by means of a quadrant electrometer, the authors found both the Hallwachs and the Lenard effects, usually superposed. Thus it may happen that some bodies dissipate a negative charge more readily, others a positive charge, while others again dissipate neither. The Hallwachs phenomenon is dominant in water, ethyl alcohol, and acetic ether, while the Lenard-effect (neutralisation of positive charge by external negative ions) is dominant in ethyl ether and in methylene bromide. E. E. F.

130. Influence of Discharge on the Photoelectric Effect. H. Greinacher. (Deutsch. Phys. Gesell., Verh. 15. 17. pp. 797-808, Sept. 15, 1918.)—The paper is a preliminary account of experiments made to test the action of the discharge in hydrogen, air, and oxygen upon the photoelectric effect of Pt, Pb, Zn, Al, Cu, and Au, these metals being used as the kathode. As observed by Elster and Geitel with Na and K alloy [see Abstract No. 1881 (1911)] the discharge in hydrogen increases the effect enormously. Air and oxygen, however, give a marked decrease. In some cases by using air and hydrogen alternately, it is possible to vary the effect repeatedly in the ratio 1 to 1000. With Zn and Al the activity imparted by the hydrogen discharge is much more permanent than with the other metals, the discharge in air having to be

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repeated several times in order to get an appreciable reduction. In the light of these experiments the peculiar results obtained on the fatigue and increase of the photoelectric effect are not surprising. The author inclines to the view that the effects observed by him are chemical in origin. F. J. H.

131. *Ionomagnetic Rotations*. A. Righi. (Phys. Zeitschr. 14. 688-708, Aug. 1, 1918. N. Cimento, 6. Ser. 6. pp. 5-38, July, 1918.)—Describes a large number of experiments to illustrate ionomagnetic rotations [Abstract No. 1877 (1912)] and works out their theory. One of the electrodes in a vacuum tube is surrounded by a very light cylinder, usually made of Al-foil 0.02 mm. thick. The other electrode is, in one form of the apparatus, coaxial with the first. The axis of the electromagnetic is vertical and coincides with that of the electrodes. The light Al cylinder is suspended vertically by a quartz or cocoon fibre. The rotations produced come to an end when the torsional moment of the fibre equals the moment of the ionic impacts. If the central electrode is a kathode, the cylinder acts as a secondary kathode, and any electron expelled from it is deflected in a more or less tangential direction. Any α -particle, due to its ionising power, which would ordinarily fall vertically upon the surface, is rotated in the same tangential direction. So the discharge proceeds round the cylinder. The author has devised a number of experiments which eliminate alternative explanations. E. E. F.

132. *Ions from Hot Salts*. O. W. Richardson. (Phil. Mag. 26. pp. 452-472, Sept., 1918.)—The chief object of the investigation is the measurement of the specific charge or the molecular weight of the emitted ions. The salts tested are: ZnI_2 , CdI_2 , CaI_2 , CaBr_2 , CaF_2 , SrI_2 , BaI_2 , Fe_2Cl_6 , and MnCl_2 . The necessary modifications of previous apparatus are briefly described. The method now adopted has the great advantage that a determination of e/m only requires a minute or two, so that the variations of this quantity can be followed even when it is changing rather rapidly. On the other hand it only gives a kind of average value if more than one kind of ion is present. The results obtained are in good agreement with those got by the previous method. In all cases the salts are heated on a flat strip of Pt which has been glowed out previously until it has lost its power of emitting ions at the temperature of the experiments. For the positive ions the following results are obtained: With ZnI_2 , unless the rather copious ionisation, when the salt is freshly heated, all arises from contamination by impurities, which seems unlikely, practically all the ions are Zn_{++} and not Zn_+ . With CdI_2 , the ions given off have an electric atomic weight corresponding to Cd_{++} . The high temperatures at which this effect is observed are against the view that the ions are produced directly by the action of heat on the iodide itself; since, at these low pressures, it would presumably have evaporated before the temperatures recorded were attained. These ions probably arise either from the action on the hot Pt of CdI_2 vapour which comes from cooler parts of the strip, or else from some less volatile substance with which the iodide is contaminated. It is possible that somewhat similar considerations apply to the ions emitted by ZnI_2 . With SrI_2 , the values of m/H are in satisfactory agreement with the chemical equivalent of $\text{Sr}_+ = 87.6$ and confirm the results obtained by Davisson with other strontium salts. With Fe_2Cl_6 there seems to be satisfactory reason for supposing that the numbers obtained indicate the presence of potassium as an impurity. With MnCl_2 , the electric molecular weight increased from 38.8 to 79.4 and then fell back to 39.2. The light ions might be Mn_{++} but on the whole Na_+ and K_+ are more probable. The

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heavy ions point to the existence of MnCl , and possibly also Mn_+ . For the negative ions the following results are obtained. With CaI , there is a very large emission of negative ions at comparatively low temperatures. This property is also shown by the iodides of the other metals of the alkaline earths. In general the negative ions emitted by these substances are not all electrons, but consist of a mixture of electrons and heavy ions. Thus when a fresh specimen of CaI is heated at a low temperature practically all the negative emission is carried by heavy ions and it is shown that these heavy ions are atoms of iodine combined with a single electron. At higher temperatures a much larger proportion of the current is carried by electrons. The iodides of Sr and Ba behave in a similar manner with respect to the emission of negative ions to that of Ca as do also CdI , although in this case the conditions are rather complicated. The other salts examined are Fe_2Cl_6 , MnCl , CaF , and CaBr . It is curious that the deviations of the observed values of m/H from the calculated values for the ions to which they are attributed are in every case, for the heavy ions examined, in such a direction as would occur if the ions in question were mixed with another kind for which $m/H = \text{about } 100$.

A. E. G.

133. *Absorption of Heat produced by the Emission of Ions from Hot Bodies.* H. L. Cooke and O. W. Richardson. (Phil. Mag. 26. pp. 472-476, Sept., 1918.)—The authors have recently shown [Abstract No. 1186 (1918)] that when a current of negative electrons is allowed to flow from a heated filament of osmium, there is an absorption of heat which is equal in amount to the energy required to drive the escaping electrons through a p.d. of 4.7 volts. The present paper deals with similar experiments made with lime-coated Pt wires and with tungsten wires. The behaviour of the former is found to be quite different from that of the osmium and tungsten wires. The turning-on of the thermionic current causes a decrease in the resistance of the wire under examination. The nature of the charge is not, however, similar to that observed with osmium and tungsten wires, but rather indicates a fairly steady rate of decrease in the resistance with the time. It seems evident that this change in resistance is not to be ascribed to a cooling effect. The data obtained would be satisfactorily explained on the assumption that this effect is due to an increase in the radiating power of the surface of the lime brought about by electrolytic effects in the lime occasioned by the passage through it of the thermionic current. With tungsten wires the change of resistance due to turning the thermionic current on or off is complete in a few seconds, and the cooling effect when the current is turned on is equal to the heating effect when the current is turned off. An erroneous statement was made in the former paper (*loc. cit.*) to the effect that a small systematic error makes the measured value of ϕ too small. It is now found that this value is too large; consequently, the suggested increase of ϕ with θ cannot be regarded as established by experiment. They are, in fact, insufficiently accurate for the purpose.

A. E. G.

134. *Temperature and Surface Conditions which affect the Positive Ionisation from Heated Platinum.* C. Sheard and D. A. Woodbury. (Phys. Rev. 2. Ser. 2. pp. 288-298, Oct., 1918.)—An experimental research leading to the following conclusions:—Two sources capable of producing thermions are present as impurities in Pt. One source of ionisation is more easily driven out by heating than the other. After continued heating, and when investigated within the proper temperature region, two distinct types of current-

time curves are obtained: one showing a decay with time from an initial maximum, the other giving rise, after two or three minutes' heating, to a maximum, followed by the usual decay effects. The thermionic emission from a wire which has lost its power of producing ions may be enhanced and made comparable with the initial effects by (a) heating in a Bunsen flame, (b) heating electrically in hydrogen, (c) cleaning the wire with acid. [See Abstracts Nos. 118 and 258 (1911)], also No. 1028 (1918).] E. H. B.

135. *The Energy of Electron Emission of Glowing Bodies.* A. Wehnelt and E. Liebreich. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1057-1062, Oct. 30, 1913.)—It is shown that with CaO the value of the emission depends upon the time, after the beginning of the glowing, at which the measurements are made. The large value for ϕ which has recently been found by Richardson has not been observed in the present experiments. It is, however, stated that the max. value of 100 volts as given by him lies in the region of probability. A further condition which must be taken into consideration in this kind of measurement is that the obtained values of ϕ are dependent on the vacuum. With pure Pt the values found for ϕ lie between 5.78 and 6.04. From these experiments it follows that the value of ϕ required by Richardson's theory for pure metals is in close agreement with the experimental results, but that CaO does not behave in accord with the theory. Further experiments are in progress. A. E. G.

136. *Ring Discharge without Electrodes.* R. Wachsmuth and B. Winawer. (Ann. d. Physik, 42. 8. pp. 585-618, Oct. 16, 1913.)—For a given excitation, continuous rarefaction reaches a pressure p_1 , at which the energy of the shock is sufficient to ionise the gas; and p_1 depends on the nature of the gas. On still further rarefaction the gas behaves as if it were exposed to a constant ionisator; the number of the ions produced and their velocity vary in a similar manner with the pressure, and the conductivity curves are entirely analogous. In this case the luminosity is feeble, and the strongest lines of the ultimate spectrum are mostly absent. On still greater rarefaction a second characteristic pressure, p_2 , is reached. At this pressure there is strong ionisation, a more intense light, and the ultimate spectrum appears in full. The numerical estimation of the energy of the shock in this case is difficult, but it is, say, from 25 to 80 times that at pressure p_1 . It varies from gas to gas, in the same order as that under pressure p_1 ; the order being He, Ne, Ar, H₂, O₂, N₂, with Hg very nearly in the same place as O₂. Hg gives a continuous spectrum at feeble ionisations, a line spectrum at powerful. At the second pressure, p_2 , a more powerful absorption of energy sets in. Photographs of spectra obtained accompany the paper. A. D.

137. *Effect of Pressure on Electric Wind from a Discharging Point.* J. R. Boon. (Phil. Mag. 26. pp. 694-701, Oct., 1918.)—An improved apparatus for the measurement of the pressure of the electric wind from point-plate discharge under different atmospheric pressures is set up and described. The curves of wind-pressure p and distance z between the electrodes agree in form at normal atmospheric pressure with those of other observers, and cut the z axis at a distance z_0 from the origin. The results at different atmospheric pressures π , in air and CO₂, show that z_0 is inversely proportional to π . This supports the view that z_0 is the result of intense ionisation possibly brought about by radiations from the point, which are absorbed in a given gas according to a density law. E. H. B.

138. Point Discharge in Magnetic and Electrostatic Fields. O. W. Silvey. (Phys. Zeitschr. 14. pp. 816-823, Sept. 1, 1918).—The discharge between fine brass points at ordinary pressure is photographed by a shadow-method in an arrangement resembling a pinhole camera of great length. By finding electric and magnetic fields which produce the same effect on the discharge, the author attempts to arrive at the velocity of the positive ions. The value obtained is 4.7×10^7 cm./sec. E. E. F.

139. Influence of Ultra-violet Light on the Discharge from Points. W. Gerlach and E. Meyer. (Deutsch. Phys. Gesell. Verh. 15. 20. pp. 1037-1046, Oct. 80, 1918).—Pringsheim has found [Abstract No. 1988 (1918)] that the discharge does not take place instantaneously when the ultra-violet light is allowed to act. The object of the present paper is to show that this so-called "lag" in connection with discharges from points is only of secondary importance. The experiments show that with negatively as well as positively charged "sensitive" points in air, when acted upon by ultra-violet light, the lag of the discharge diminishes with decreasing pressure. From this it is concluded that this lag with regard to the photoelectric effect can only be considered of secondary importance. With the lower pressures employed the lag diminishes with increasing intensity of light. A. E. G.

140. Pressure Gradient produced in Gaseous Discharge by a Transverse Magnetic Field. H. Sirk. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 417-475, Feb., 1918).—On the assumption that the discharge in a gas is a convective transport of charged particles and that the mean free path of these is small compared with the dimensions of the discharge tube, the pressure-difference which should be produced across the discharge upon the establishment of a transverse magnetic field is calculated. If H is the value of this field, j the current density, and l the width of the discharge measured at right angles to the magnetic field, the pressure-difference in this same direction produced by the magnetic field is given by the equation $\Delta p = Hjl$. Experiments are described by which this formula is tested. A torsion manometer of special construction, which together with its calibration is fully described in the paper, is used to measure the very small pressure-difference produced, being attached to tubes sealed to the discharge tube at opposite ends of a diameter. Tables of results with various forms of discharge tube are given, which show that the effect is proportional to the magnetic field and to the current, and also that it is reversed with a reversal of either of these. The form of discharge tube found to be most suitable for obtaining results with which to test the theory is one having large Al electrodes at the ends of a constriction into which the pressure sounds are sealed. A good agreement is obtained between the observed and calculated values of the pressure-difference across the tube. F. J. H.

141. Heating Effects at the Kathode in Vacuum Tubes. B. Hodgson and P. A. Mainstone. (Phil. Mag. 26. pp. 411-422, Sept., 1918).—The paper is a continuation of the work of one of the authors [see Abstract No. 1187 (1918)]. The quantity of heat energy communicated to the kathode is determined by its rise of temperature, measured by a mercury thermometer, and is found to be proportional to the current while the kathode glow is normal, but with the abnormal glow the heat given increases more rapidly as the current increases. Determinations of the rates of cooling of the kathode at various temperatures and of its thermal capacity enable the authors to obtain the

quantity of energy communicated per sec. On the assumption that the whole of the current at the kathode is carried by positive ions, the product of the current and kathode-fall should also give this amount of energy. The amounts of energy obtained by these two methods are found to be the same with oxygen and hydrogen. Measurements with air, and nitrogen containing traces of oxygen revealed the fact that in both cases the positive ions bombarding the kathode had fallen through the kathode fall of potential for oxygen. Irregularities in the readings were found to be due to the gases coming off from the electrodes.

F. J. H.

142. Rotations in the Iron Arc. W. G. Cady. (Phys. Rev. 2. Ser. 2. pp. 249-269, Oct., 1918.)—The author has described in previous papers the rotation found at the anode of the iron arc in air [see Abstract No. 115 (1908)]. Subsequent experiments have shown that the phenomenon is more complicated than was at first supposed. Stated briefly, the phenomena are as follows. When the anode is sufficiently oxidised, so that a smooth molten globule of oxide is formed, the positive base of the arc has a tendency to rotate, the appearance produced being that of a minute ring of light at the anode. As the current is increased from about 1.5 to 2.5 amps., four characteristic types of rotation are successively observed. The transition from one type to the next is marked by a distinct and sudden change in the diam. of the ring and the speed of rotation of the arc. This is the normal sequence of events in the iron arc as the current increases. Up to about 1.5 amps. the anode globule, though brightly incandescent, is not being converted into vapour. In this stage there is only a glow discharge at the anode. At about 1.5 amps. the current jumps abruptly one or two tenths of an amp., and the second stage begins. In this case the positive base of the discharge is concentrated on a spot similar to that at the kathode, and a hissing sound is heard due to the vaporisation. A close examination of the magnified image shows that the positive base is in the form of a ring having a dark centre. In certain cases a faint wavering high-pitched note can be heard. This is the first of the four types of rotation (type A). The second (type B) begins when the current lies in value between 1.67 and 1.73 amps. The ring has a smaller diam., and the rapidity of the rotations is greater than in type A. At 1.80 amps. type B suddenly changes to type C. In this case the diam. of the ring is much larger, and the rapidity of the rotations is much smaller. This type is by far the most conspicuous, and is the one the author described in his early papers. This arc makes an audible note. At 1.88 amps. the fourth type of rotation D begins. In air this type lasts up to about 5 amps. With increasing current the frequency falls and the diam. increases; above 8 amps., however, the motion is very irregular. The author considers that the rotations are probably due to modifications in the composition of the globule of oxide at the anode.

A. R.

143. Damping of Oscillatory Discharges. F. L. Talamo. (N. Cimento, 6. Ser. 6. pp. 48-58, July, 1918.)—Determines the damping of electric oscillatory spark discharges in air by a modification of Rutherford's method. The damping increases with the pressure, rapidly at first, and then more slowly (between 96 and 186 cm. of mercury), and finally again rapidly. The damping decreases with increase of sparking distance to a minimum at 4 or 5 mm. This contradicts Brooks, but agrees with Beaulard, Zenneck, and Drude. On reducing the pressure, the damping decreases at an approximately uniform rate. The influence of the spark-length is in the same direction at all pressures.

E. E. F.

144. *The Goldschmidt Dynamo and Electromagnetic Wave Transmission.* O. Lodge. (Phil. Mag. 25. pp. 757-791, June, 1918. Electrician, 71. pp. 767-770, Aug. 15, 1918. Abstract. Jahrbuch d. drahtlosen Telegraphie, 7. pp. 514-521, Nov., 1918.)—Gives a theory of the Goldschmidt generator for high-frequency currents, together with a discussion concerning the propagation of ether waves through the atmosphere, with especial reference to the curvature of the earth. In the first part there is a description of the general principle of the Goldschmidt generator, with the differential equations for the action and reaction currents in the rotor and stator. These equations are—

$$x = M/R \cdot d/dt \cdot (y \cos pt)$$

and

$$y = y_0 + M/R' \cdot d/dt \cdot (x \cos pt),$$

where x is the rotor current, y the stator current, and M the mutual induction when the poles are opposite each other. These equations are worked out in steps, and it is shown that the rotor currents are arranged according to sine functions of the odd multiples of the fundamental frequency, whereas the stator currents are arranged according to cosine functions of the even multiples of the same frequency. This solution is carried out for all frequencies up to the factor 10, and the general law of coefficients is indicated. Special attention is devoted to the practically important case in which the highest factor is 4. In an appendix the above equations are treated more rigidly and general solutions are given in various forms. The final series, representing the complete solution, appears divergent, but in practice this divergence is limited by the condition that the higher frequencies do not occur when no tuning is provided for them. The second part gives an expression for the radiating effect of an antenna in kw. referred to the mean value of the antenna current. For continuous oscillations this formula is cA^2P/λ^2 , where A is the mean current in amps., l the effective length of the antenna, λ the wave-length, and c a constant near unity. Some considerations are put forward with regard to the best construction of antennæ, especially for directed radio-telegraphy. The free capacity and the height offer two independent means of increasing the wave-length without reducing the radiation intensity. The introduction of inductances in the antenna means a lengthening of the wave without an increase of field in the distance, though the loss of radiation effect is compensated to some extent by greater tuning facility. The importance of a great height for the upper capacity is so pronounced that it might be advisable to use a hill, or pair of hills, for supporting the upper ends. The cause of the interference of sunlight with the range of signalling is not yet clear. The author inclines to attribute it to an interference with the horizontality of the limiting layer of the conducting upper atmosphere. The conductivity of the latter may be largely due to electrons of solar origin, and these are accelerated by the passage of an ether wave. Thus, a Hertzian oscillator with an antenna current of 600 amps. is capable of imparting a velocity of about 1 km. per sec. to an electron at a distance 10 times the length of the antenna. If sunlight liberates, say, 10,000 electrons per cm.² per sec., a considerable reduction in the strength of the waves must result. P. O. Pedersen. (Electrician, 71. p. 741, Aug. 8, 1918.)

E. E. F.

145. *Radiation of Electric Waves from a Point above the Earth's Surface.* K. Wolf. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 197-281, Feb., 1918.)—A VOL. XVII.—A.—1914.

mathematical treatment of the space and surface waves in which it is shown that the latter are damped as $r^{-1/2}$, whereas the former are damped as r^{-2} . The solution obtained does not, however, admit of so ready a separation of the two waves as that of Sommerfeld. [See Abstract No. 569 (1912).]

E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

146. *Action of Mercury-vapour on Selenium.* F. C. Brown. (Phys. Rev. 2. Ser. 2. pp. 158-160, Aug., 1918.)—Mercury-vapour acts on selenium in such a manner as to produce a very high conductivity and an increase of resistance on illumination. The mercury acts on the amorphous form and probably also on the other modifications so as to produce selenium of new characteristics. Permanent chemical compounds are probably formed between the mercury and the selenium. An easy and satisfactory method of making light-negative Se is to place the amorphous Se in a mercury vacuum until it becomes black, and then to press this black Se between fixed electrodes.

E. E. F.

147. *Distance between Conducting Plates and Question as to Electron Atmospheres.* F. C. Brown. (Phys. Rev. 2. Ser. 2. pp. 814-822, Oct., 1918.)—In 1912, R. W. Wood [see Abstract No. 865 (1918)] raised the question as to the existence of conducting atmospheres surrounding metallic surfaces. This hypothesis arose from a number of experiments, in which electrical conduction took place between metallic surfaces separated by 20 or 80 wave-lengths of sodium light. The present author measured the distance between plates by using them as a condenser. He thus concludes that there was almost perfect insulation when the two plates were separated by ten wave-lengths and that conduction did not extend so much as two wave-lengths outside the mechanical surface.

E. H. B.

148. *Conductivity of Thin Liquid Films.* A. Ungerer. (Phys. Zeitschr. 14. pp. 685-688, Aug. 1, 1918.)—Films of NaCl or HgNO₃ solution having a thickness of the order of 10^{-4} mm. show no conductivity differing from that measured by ordinary methods, whereas many previous researches on soap films and metallic films have shown a dependence of specific conductivity on thickness. The thickness of the films was gauged by means of Newton's rings. Of two thick plates of glass, one was provided with a cylindrical boring into which a silver plate was inserted to serve as an electrode. This plate was pressed on to the other plate by means of six screws, and the pressure was so regulated that Newton's rings were concentric with the bore. A silver ring surrounding the junction between the plates was the second electrode. Thus the film of the required thickness could be reproduced at any time. The agreement between the observed conductivity and the ordinary conductivity was correct to within 8 per cent.

E. E. F.

149. *Influence of Conductivity on the Apparent Dielectric Constants of Liquids.* W. M. Thornton. (Univ. of Durham Phil. Soc., Proc. 5. pp. 19-25, 1912-1913.)—The behaviour of a conducting dielectric may be examined by direct measurements with steady currents or by observation of capacity currents in alternating fields. The latter case is complicated by the fact that any expression for the charge on the boundary surface contains the

product $K\rho$ of the true dielectric constant K and the resistivity ρ , and both may be influenced by changes of frequency and in the composition of the substance. The state of knowledge regarding the dielectric constants of liquids is reviewed. When measurements are made on water by contact methods K is found to be constant at 80 over a wide range of frequency. But when water is enclosed in a quartz ellipsoid suspended in a Hertzian field, so that there is no contact between the electrodes and the liquid, K falls to 8 and decreases with increase of frequency. Similar differences are observed with the alcohols. It is therefore clear that the dielectric constants of liquids other than electrolytes are affected by arranging the experiment so that no conduction currents can flow. From considerations regarding the variation of the resistivity and the refractive index of salt solutions it is deduced that the variation of K with concentration must be small. The resistivity of a conducting dielectric is the dominating factor in its behaviour in alternating fields even at high frequencies. In conclusion it is suggested that the high values of K for water and alcohol should be considered as dependent more on the electrical conductivity of the medium than upon true polarisation. The conductivity considered is that of electronic mobility within the molecule rather than of ionic mobility through the fluid.

H. W. M.

150. Experiments on Tinfoil Contact with Dielectrics. G. E. Bairsto. (Phys. Soc., Proc. 25. pp. 801-820; Discussion, pp. 821-823, Aug., 1918.)—The points examined are:—(1) The different effects of pressure and voltage upon tinfoil contact with celluloid as dielectric. (2) The effect of contact upon measurements made with alternating currents. (3) The effect of imperfect contact upon the accumulation of residual charge. Appleyard [see Abstract No. 2099 (1905)] has described experiments with a condenser having tinfoil electrodes and found the apparent resistance to decrease gradually at first with increase of pressure, but finally a practically constant value resulted. Increasing the voltage was found to decrease the apparent resistance. The tests made by the author clearly show that voltage has quite as much effect as pressure in bringing about an intimate contact with tinfoil electrodes and would also seem to indicate that each acts independently of the other. By considering the geometry of the tinfoil humps an explanation of the various effects is given. For measurements of the alternating-current conductivity the influence of the bad contact is twofold. Firstly, it decreases the apparent capacity by inserting in series with the condenser under test a very large air condenser. Secondly, because of the decrease in area of contact, it decreases the magnitude of that component of the conductivity which is independent of the frequency—i.e. the purely ohmic conductivity. By considering the system as equivalent to a leaky condenser in series with a very large capacity, expressions are deduced for the equivalent capacity, conductance, and power factor. Finally, the influence of imperfect contact upon the accumulation of residual charge is considered. It is shown that if we have a condenser with tinfoil electrodes the recovery of a residual charge is obscured by the presence of creeping surface charges coming out of the undischarged portions of the dielectric, leading to an apparent residual charge greater than the true residual charge left in the dielectric.

F. E. S.

151. Capacity of Wire Netting. P. O. Pedersen. (Jahrbuch d. Drahtlosen Telegraphie, 7. pp. 484-488, Sept., 1918.)—The problem of calculating the capacity of a wire netting parallel to a conducting surface is approached by a

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consideration of the corresponding problem for current. The average capacity, C_0 , per sq. cm. is given by

$$C_0 = 1/2i \left[\log (e^{2\pi a/d} - e^{-2\pi a/d}) + \log \frac{d}{2\pi p} \right].$$

Here d = distance between two neighbouring wires of the netting, a = distance between netting and conducting surface, p = radius of the wire of the netting.

T. P. B.

152. Resistance Unit of the Physikalisch-Technische Reichsanstalt. W. Jaeger and H. v. Steinwehr. (*Zeitschr. Instrumentenk.* 33, pp. 293-305, Oct., 1918. Communication from the Physikal-Techn. Reichsanstalt.)—A detailed account of measurements on many resistance standards. The Reichsanstalt have 5 mercury standards of resistance and have 5 others in course of construction. Comparisons from time to time show that the principal manganin resistance standards have kept very constant during the past 20 years, the max. variation being 22 parts in a million. Observations on the effect of variable atmospheric humidity on unsealed coils of manganin have been continued, and the conclusion is that changes due to such a cause are, in general, very small. Changes of 1 part in 1000 can only occur in badly constructed coils, and such changes will occur whether the coils are hermetically sealed or not. The results of certain international comparisons show that the mercury standards of resistance of the Reichsanstalt and of the National Physical Laboratory differ by less than 2 parts in 100,000 and that the resistance units used at the Bureau of Standards, Washington, and at the Laboratoire Central d'Électricité, agree with those of the two laboratories previously mentioned within about 2 parts in 100,000.

F. E. S.

153. The Silver Voltmeter. E. B. Rosa, G. W. Vinal, and A. S. McDaniel. (Bureau of Standards, Bull. 9, pp. 493-551, Jan., 1913. *Elektrotechn. Zeitschr.* 84, pp. 1168-1169, Oct. 9, 1913. Extract.)—In the present series of experiments attention was directed to the porous cup and non-septum form of voltmeter, the apparatus and methods being similar to those previously employed [see Abstract No. 501 (1913)]. With the small porous cup voltmeter and silver nitrate believed to be pure an average value of 1.01827, int. volts was obtained for the Western normal cell at 20°C., the average deviation of a single determination from the mean being 8 parts in 100,000. With the large porous cup voltmeter heavier deposits by 6 parts in 100,000 were obtained and with the siphon voltmeter the deposits were 80 parts in 100,000 heavier than with the small porous cup voltmeter. The filter-paper voltmeter gave results varying with the amount of paper immersed in the solution, but the mean was about the same as obtained with the siphon form; the Poggendorf voltmeter gave results about 7 parts in 100,000 greater than those obtained with the small porous cup. Further experiments with the siphon showed that when a porous cup was placed over the kathode end of the siphon a lighter deposit of silver resulted. In general, the larger the size of the voltmeter the heavier was the deposit, and this effect was called the "volume effect." With pure solutions there should be no such effect. With regard to used solutions, they are purer than the original solutions if the latter were impure. For testing the purity of silver nitrate special methods have been devised. Estimations of the acidity may be made within 1 part in 100,000 using iodeosin as an indicator. For testing the

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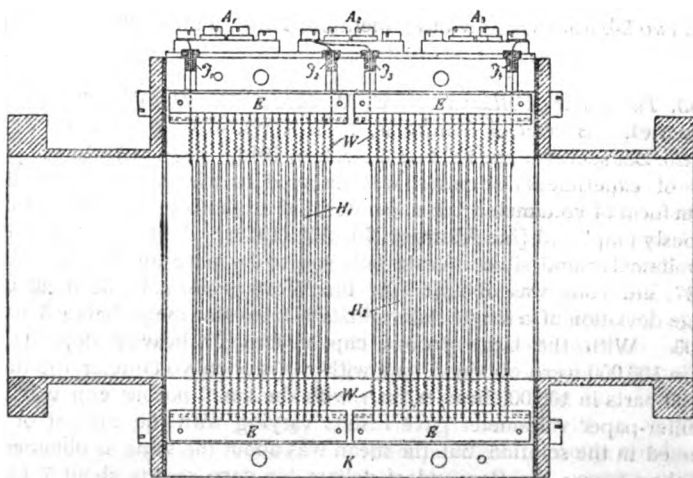
solutions for reducing agents and colloidal silver, 100th normal potassium permanganate is employed. Methods of preparing pure silver nitrate are fully described, the fusion of the salt being discussed with particular reference to its decomposition after all of the acid has been expelled. The temperature-coefficient of the voltameter was found to be zero and deposits on gold and platinum kathodes are in agreement.

F. E. S.

154. Metallic Rectifiers. W. Winter. (Phys. Zeitschr. 14. pp. 823-828, Sept. 1, 1918).—Besides aluminium, many metals show a rectifying electrolytic action when the precaution is taken of introducing a porous substance, such as unglazed earthenware, between the electrolyte and the metal acting as an anode. The author examined a number of metals in this way, using carbon as a kathode, and allowing for the slight voltaic current due to the difference of electrode material. In dilute KHO the following metals showed a rectifying action: Mg, Al, Zn, Cd, Fe, Co, Ni, Pb, Sn, Sb, Bi, Cu, Ag, Pt, Au, and Cr. All these, except the three last, also acted in dilute H_2SO_4 . Gold amalgam on gold also acted in dilute H_2SO_4 . The enhanced action due to the porous partition is ascribed by the author to the greater concentration of the dissociation products.

E. E. F.

155. Electrical Anemometer. H. Gerdien. (Elektrotechnik u. Maschinenbau, 81. pp. 893-895, Oct. 19, 1913. Paper read before the 85. Naturforscherversamml. Vienna.)—The apparatus described has the following advantages: (1) Readings may be taken quickly, (2) absence of moving parts,



(8) measurements may be recorded at a distance. The stream of gas to be measured passes through a tube in which two Pt-wire resistances are suspended. The resistances (H_1 and H_2 of the Fig.) are stretched in zigzag fashion in a diametral plane of the tube (the plane of the figure), and are kept taut by Pt-Ir springs (W) which are fixed to ivory blocks (E). These two resistances form arms of a bridge, which is adjusted so that the galvanometer reads zero when no gas flows through the tube, and the battery maintains a current in them which raises their temperatures about 50 deg. C. above that

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of the gas. When a current of gas passes the resistances they are cooled unequally and a galvanometer deflection results. The instrument must be calibrated for the particular gas in which it is to be employed. For measuring the stream of gas in a large pipe the measuring tube is connected in parallel with it so as to shunt a definite proportion of the stream. To measure wind velocities the apparatus is connected by tubes to the front and back of a baffle-plate kept normal to the wind. A temperature compensation device is described for use in this connection and also an arrangement which enables the velocity of the wind and its inclination to the horizontal to be simultaneously determined.

F. T. C.

156. Electric Properties of Tempered Steel. U. Bordoni. (N. Cimento, 5. Ser. 6. pp. 412-486, June, 1913.)—The effect of the temperature to which the steel is heated for being tempered in a liquid at ordinary temperature is examined, both in the case of the thermoelectric property and of specific resistance. The methods of heating and of quenching are described, and also the experimental arrangements for measuring the electric properties. Six kinds of steel are examined, the results being the same qualitatively but differing quantitatively. For measuring the thermoelectric effects a steel-copper couple is used, and it is found that before tempering the steel has a small negative thermoelectric power with respect to copper, but this continuously changes to a considerable positive value as successively higher temperatures are used for the heating required for tempering. The rise is rapid at first, but eventually becomes slow, a limiting value being approached. At the same time the resistivity falls, also rapidly at first but slowly afterwards, and simultaneously the coefficient of increase of resistance with temperature rises by a very small amount. The effect of tempering in liquids of different temperatures is also touched upon.

S. G. S.

157. Astatic Vacuum Radio-micrometer. K. P. Jakovlev. (Russian Physico-Chemical Soc., Journ. 44. No. 8. pp. 459-469, 1912.)—To overcome the defects of want of sensitiveness manifested in earlier radio-micrometric apparatus the author uses the principle of astaticism, a thermopile being placed inside the gap. The thermo-element is composed of a Pt and gun-metal wires 0.02 mm. in diam., soldered together so as to form a butt joint. The period without the magnetic field is 26.2 secs.; within field, 7.0 secs. The sensibility rises from 90.1 with a period of 7 secs., to 740 at 21.9 secs. Numerous details of construction of the instrument are given, and the effect of vacuum is examined, the results being given in the table below :—

EFFECT OF VACUUM.

Pressure in mm.	Deflect. on Scale.	Pressure in mm.	Deflect. on Scale.
760	9.5	760	11.0
7	10.1	6	11.8
1.15	14.15	0.51	21.65
0.49	19.3	0.12	43.5
0.10	38.5	0.089	68.75
0.044	52.45	0.02	82.0
0.021	65.6	0.011	88.5
0.008	77.0	0.0028	96.7
0.0038	82.0	0.0008	100.5
0.0016	85.0	0.0002	101.0
0.0008	87.8		
0.0002	87.8		

I. P.

158. *An Interrupter for Heavy Currents.* **B. Thieme.** (Phys. Zeitschr. 14. pp. 904-905, Sept. 15, 1918.)—Instead of using high-frequency transformers, the author proposes a high-frequency interrupter in a 220-volt circuit. The interrupter consists essentially of a brass or copper disc with a smooth rim, kept in rotation by a motor. A carbon rod is pressed tangentially against the rim. The trace of eccentricity invariably present suffices to interrupt the current. The arc is drawn out in the direction of motion of the disc, but as the pressure and the speed are increased the arc shortens, and at a certain critical pressure the contact becomes continuous. A pure note may be obtained by choosing a speed of rotation in resonance with the period of transverse vibration of the rod. The current interrupted may be as strong as 15 amps. The rod has to be tightened about every half-hour, but the disc keeps cool and shows no wear. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

159. *Alternate Currents Demonstrated by Manometric Flames.* **H. Nagaoka.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 116-118, July, 1918.)—The alternate character of currents may be demonstrated by an electromagnet acting on the membrane of a manometric flame. The frequency can be ascertained by comparison, in a rotating mirror, of the pattern of flames due to the alternating current with the pattern of flames due to a source of sound of known pitch. E. H. B.

160. *Effect of Thermal Treatment and of Longitudinal Strain in Inducing Sensitive State.* **M. B. Moir.** (Roy. Soc. Edinburgh, Proc. 88. pp. 248-256, 1912-1918.)—In carbon steel the most susceptible part of the temperature scale in producing sensitive state is about 150° C. [see Abstract No. 2023 (1908)], whereas in tungsten steel the corresponding temperature is about 800° C. the effect being much smaller. Longitudinal strain has an effect similar to that caused by thermal treatment. The results in each case are given for five different specimens. G. E. A.

161. *Coercive Force of Nickel.* **R. Gans.** (Ann. d. Physik, 426. pp. 1065-1072, Dec. 28, 1918. Phys. Zeitschr. 14. p. 881, Sept. 1, 1918.)—Determines the coercive force of Ni from the temperature of liquid air up to 612° C. It ranges from 29 to 8918 gauss. If C is the coercive force at T° abs., and C_0 the same at the absolute zero (29.4 gauss), then the results are given by $C/C_0 = 8L(x)/x$, where $L(x) = \coth x - 1/x$. Also, $T/\theta = L(x)$, where θ is Curie's temperature of disappearance of ferro-magnetism. Weiss makes this 681° C. E. E. F.

162. *Effect of Changes of Electrical Resistance upon Magnetisation of Nickel.* **C. G. Knott.** (Roy. Soc. Edinburgh, Proc. 88. pp. 200-224, 1912-1918.)—In a former paper [Abstract No. 1159 (1904)] the author described observations on the relation between magnetisation and resistance in nickel at high temperatures, the magnetisation being along the direction in which the resistance was measured. Later a series of measurements was made in which the magnetisation was transverse to the direction in which the resistance was measured. In these later measurements a flat coil of nickel wire was used and very high fields were necessary. The results indicated that the magnetisation, and not the magnetising force, was the determining factor. Thus the form of the material employed was important and thin
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nickel sheeting was used, the change of resistance of a nickel strip when magnetised transversely being easily measurable in moderate fields when sensitive apparatus was employed. In the present paper the results of measurements made when nickel was subjected to a combination of two fields, longitudinal and transverse at the same time, are described. A strip of Ni of width 2.1 cm. and of resistance 0.0878 ohm was doubled over and rolled up like a tape measure so as to form an anchor-ring core for a transformer-wound coil. The neighbouring turns of the Ni were insulated by interleaved asbestos sheeting, and the magnetising coil was wound round in two layers, there being 57 turns in the inner layer and 51 in the outer. The coil finally formed a roughly elliptical anchor ring with external diams. 4 and 8.5 cm. and interior diams. 1.7 and 1.8 cm. In this regarded as electromagnetically equivalent to a circular anchor-ring of radius 1.81 cm. one ampere passing through the magnetising coil will produce an average field of 16.5 gauss. This coil was then placed axially in the gap of a solenoid consisting of 6 large coils placed end to end, 3 on each side of the gap. The field within the gap for various currents passed through the solenoid was measured by means of a Bi coil. The lines of magnetic force due to this field ran across the nickel, i.e. transversely to the magnetic field established in the anchor-ring coil enclosing the strip. The nickel strip was made to form the greater part of one arm of a Wheatstone bridge, an approximate balancing being secured by adjustment of the point of contact on a stretched wire. By suitable arrangements the proportionate change of resistance in the arm containing the nickel was readily calculated, a calibrating shunt being used to change slightly one of the known resistances of the bridge. A full record of the results obtained is given in the paper in a series of tables and the significance of the numbers is shown clearly by means of a set of representative graphs. The phenomena may be summarised thus:—

- (1) When a nickel strip is conveying a current its conductance is diminished in a longitudinal magnetic field, increased in a transverse magnetic field.
- (2) Reversal of either magnetic field does not change the accompanying effect on the conductance.
- (3) When a cyclic longitudinal field is superposed upon a steady transverse field of magnitude less than a certain critical value the diminution in the conductance is less marked as the transverse field increases and practically vanishes when this critical value of transverse field is reached.
- (4) When the steady transverse field exceeds this critical value the superposed cyclic longitudinal field causes an increase in the conductance, and this increase becomes more marked as the longitudinal field is made greater.
- (5) When a cyclic transverse field is superposed upon a steady longitudinal field the increase in conductance is augmented. Not only does the increase of conductance grow greater with the stronger transverse field but it also grows greater as the steady longitudinal field is increased. The observed effects are evidently due to a remarkable molecular and intermolecular action. The explanation according to the electron theory is discussed, but the author concludes that no simple theory of orientation of magnetic molecules can at all fit in with the facts. An explanation must be sought in some more complex process in which the grouping of the magnetic molecules and even the internal structure of each magnetic molecule are of fundamental importance.

J. J. S.

from the Phys. Lab., Leiden.) [See also Abstract No. 693 (1918).]—The authors first give a table of results for crystallised manganese sulphate, whereby it is shown that down to and at nitrogen temperatures the law of Curie is obeyed. The case of the anhydrous salt is then dealt with, the water having been expelled from the crystallised variety by heating. Here divergence from Curie's law over the whole field of low temperatures was found, although down to nitrogen temperatures it is only a disturbance of the first kind. At hydrogen temperatures, however, a further disturbance occurs not unlike those with solid oxygen. The authors point out the analogy with crystallised ferrous sulphate, where the presence of molecules of water of crystallisation causes a diminution of the quantity Δ' to a very small value in comparison with that of the anhydrous substance. Further observations upon pure ferrous and ferric sulphates are then recorded, since the previous specimens investigated in Com. No. 129b were found to have been contaminated. The quantitative result arrived at in Com. No. 129b concerning the appearance of the first kind in Curie's law, and the possibility of finding the constant of Curie for these substances by means of a correction, is found to retain its value. Should the disappearance of Δ' with the introduction of water molecules be ascribable to the increase of distance between the iron atoms which is caused thereby, then Δ' should decrease with increase in number of molecules of water of crystallisation, and the authors therefore intend to examine a salt which crystallises in a series of different hydrates so as to ascertain whether Δ' depends on the density. A table of results is next given for pure Pt, while a reference to dysprosium oxide is made. The susceptibility of liquid oxygen has previously been determined by H. K. Onnes and Perrier in two ways, and now follows a third by the attraction method whereby an evacuated cylindrical glass tube is hung in the magnetic field and the repulsion experienced by the tube is measured when the surrounding space is filled with liquid oxygen. Tables are given, and the results discussed. A private communication by Weiss is then quoted, in which it is suggested that there might be discontinuity in the region between 0°C. and -138°C. Finally, experiments still incomplete are referred to, in which it appears probable that gaseous oxygen of 90 times the normal density obeys Curie's law down to -180°C.

H. H. Ho.

164. Magnetic Researches. VIII. The Susceptibility of Gaseous Oxygen at Low Temperatures. H. Kamerlingh Onnes and E. Oosterhuis. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1404-1406, July 15, 1913. Communication No. 134d from the Phys. Lab., Leiden.)—The paper deals with results for compressed oxygen between 17°C. and temperatures near the critical temperature. The attraction method previously noticed was used for the determinations, and a graphic representation is given of the data obtained. Within the limits of accuracy in the measurements a Δ does not yet appear in oxygen above the critical temperature at densities which are 100 times the normal. From this it seems all the more probable that Δ only appears for oxygen at great densities, and in liquid oxygen can rise to the considerable value of 71° as the density rises to 1000 times the normal.

H. H. Ho.

165. Magnetic Researches. IX. Deviations from Curie's Law in Connection with the Zero-point Energy. E. Oosterhuis. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 432-440, Nov. 27, 1913. Supplement No. 81 to the Communications from Phys. Lab., Leiden.)—The paper commences with a

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review of known deviations from Curie's law, which is that for a number of paramagnetic substances the susceptibility is inversely proportional to the absolute temperature. Onnes with his collaborators found that a substance which follows the law at higher temperatures may begin to deviate from it at lower. This investigation at low temperatures promised to give an insight into the nature of paramagnetism, and from the results obtained with several substances the author and Onnes were led to the conception that for all paramagnetic substances, or at least for one class of them, the deviations from Curie's law are governed by a law of corresponding states, the corresponding temperature for each substance to be taken proportional to a certain temperature characteristic of that substance. The majority of the substances investigated in the cryogenic laboratory at Leiden may be reduced to the following three types: (a) Those such as crystallised ferrous or manganese sulphate, etc.; where the relation $\chi T = \text{const.}$ holds as far down as the temperatures of liquid nitrogen, but where at hydrogen temperatures χT was always smaller than would follow from Curie's law. (b) Those such as anhydrous manganese sulphate in which the product χT began to diminish at once when the temperature was lowered below room-temperature; in this case $\chi(T + \Delta) = \text{constant}$ held up to nitrogen-temperatures, but failed in liquid hydrogen. (c) Those such as Pt, in which the susceptibility appeared almost independent of temperature. The author then puts forward a theoretical explanation of the deviations from Curie's law. The latter was theoretically deduced by Langevin in his kinetic theory of paramagnetism where the susceptibility is found to be inversely proportional to the kinetic energy of rotation of the molecules. This latter assumption is dropped by the present author in favour of a different temperature relation based on Einstein and Stern's work for the rotational energy; and a mathematical demonstration is then given accompanied by illustrative tables, which show the inclusion of a zero-point energy to be necessary. Reference is also made to results obtained by a different formula which takes into account the possibility of more than one frequency of rotation, whereas Einstein and Stern assumed that at a definite temperature all the molecules rotate with the same velocity. In conclusion, the author summarises the various investigations which have made probable the existence of a zero-point energy as follows:—(1) The change of the specific heat of hydrogen at low temperatures has been explained by Einstein and Stern in a satisfactory manner by the assumption of a zero-point energy. (2) The assumption of a zero-point energy for the translational motion of gas-molecules appears to be also required. (3) Keesom has shown that the quanta theory with the additional assumption of a zero-point energy is of great importance in the theory of free electrons in metals, and removes a number of difficulties inherent in the equipartition-theory. (4) In the present paper it is shown that the assumption of a zero-point energy for the rotations finds a strong support in the observations on the susceptibility of paramagnetic substances; it appears that by means of it the majority of the deviations from Curie's law observed at low temperatures may be correlated and quantitatively explained in a satisfactory manner.

H. H. Ho.

166. *Change of Length in Magnetite with Magnetisation.* K. Yamada. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 170–174, Oct., 1918.)—Two elongated rectangular specimens of nearly pure magnetite were tested for change of length by means of a simplified form of the apparatus used for a similar purpose by Nagaoka. Hysteresis curves were first drawn, from which it appeared that the coercive force of magnetite is greater than that of soft

iron, and the intensity of magnetisation is about half that in nickel. The energy dissipated during a cycle (for $H = \pm 288$) was 54,400 ergs. The change of length takes place very slowly in weak fields, but goes on gradually increasing at a steady rate, so that max. elongation was not observed in a field of several hundred gauss. The hysteresis in elongation is quite remarkable, and resembles that in iron in weak fields. When elongation is plotted against magnetisation, the hysteresis is nearly evanescent, showing that elongation and magnetisation are intimately connected in the cycles. G. E. A.

187. *Sun's Influence in Magnetic Storms.* A. L. Cortie. (Roy. Astronom. Soc., M.N. 73. pp. 589-548, May, 1918.)—In former papers the author has pointed out that an area of sun-spot disturbance may be accompanied by several magnetic disturbances as it traverses the sun's disc. Such storms occur in batches, sometimes on several succeeding days, the angular separation of the sun-spot and the earth's position in heliographic longitude being at times considerable. Evidence of a type of localised effect, due possibly to sets of rays or streamers, has been adduced from the discussion of eclipse pictures of the solar corona [see Abstract No. 1784 (1918)], and in the present paper additional evidence of this nature has been collected from the eclipse results of 1898, April 16. The results on the whole appear to strengthen the view that the mode of influence is in the form of rays diverging from loci of sun-spot disturbance, such rays being probably carriers of negatively-charged electrons. As these particles recede into space they would repel each other, resulting in the formation of clouds of particles. The double curvature of some of the streamers of the solar corona appears to be evidence of some such mutual repulsion. C. P. B.

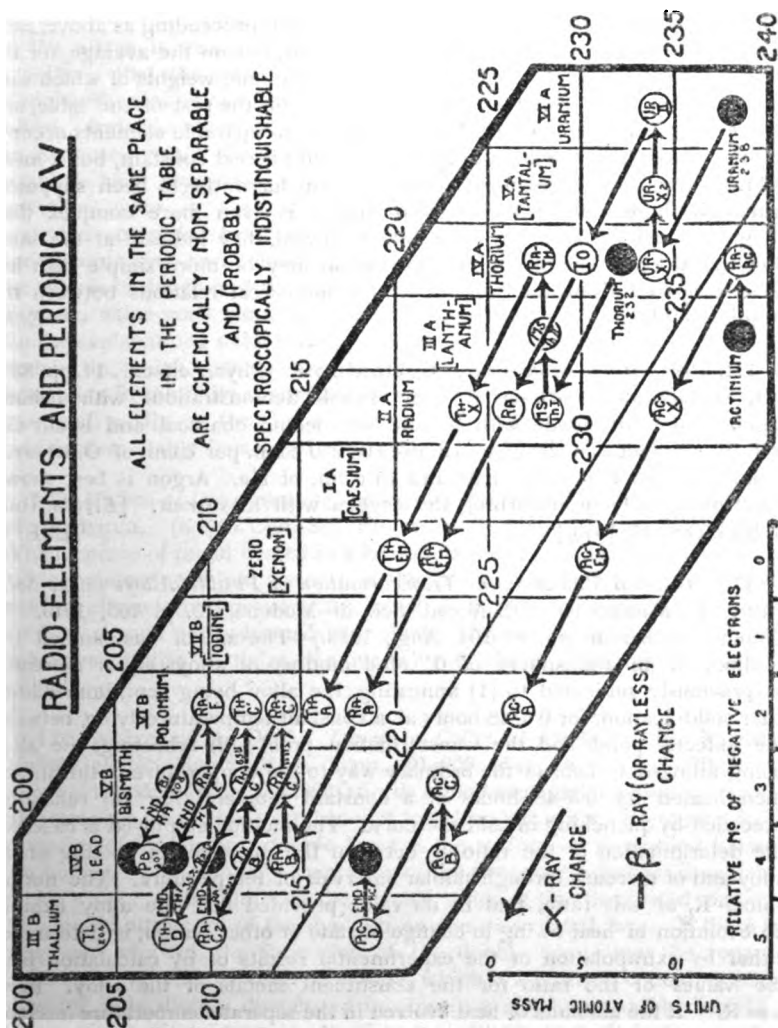
RADIOLOGY AND ELECTROPHYSIOLOGY.

168. *Determination of the Time of Exposure of a Radiograph.* T. Nogier. (Archives d'Él. Médicale, 21. pp. 868-874, Oct. 25, 1918.)—The exposure tables of Grisson, and also that of R. Heller and Mylius are given and explained. A diagram of the exposure time indicator of Gaiffe is given and these three methods of obtaining the correct time of exposure are compared. It is concluded that the figures given by Grisson and Gaiffe represent a minimum of exposure below which it is not usually possible to obtain a good negative, while those of Heller and Mylius represent a maximum of exposure above which the image becomes very black and the negative very dense. The Gaiffe indicator is recommended on account of the fact that all conditions of exposure are taken into consideration. A. E. G.

169. *Means of Avoiding Burns by Röntgen Rays.* M. Ménard. (Comptes Rendus, 157. pp. 868-870, Nov. 10, 1918.)—A general protective arrangement with lead is described and, after a discussion on gloves in common use, which are by no means satisfactory in preventing the passage of the harder rays employed, a new glove material is described. It consists essentially of an indiarubber tissue in the composition of which salts of a metal of high atomic weight are employed. With gloves of this material 4 mm. in thickness, the hands of the operator are completely protected even against very hard rays. The complete outfit is regarded as capable of preventing any injurious results when using Röntgen rays. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

170. Radio-elements and the Periodic Law. F. Soddy. (Chem. News, 108, pp. 168-169, Oct. 3, 1913. Abstract of paper read before the British Assoc. at Birmingham.)—A *résumé* of recent work on the passage through the periodic table of the elements in process of radio-active change [Abstracts Nos. 1074,



1075, and 1079 (1918)]. The author shows that it is possible to write the three disintegration series of Ur, Th, and Ac across the periodic table, so that each member falls into its proper place as above: the general law is that in an α -ray change the element changes its place in the periodic table in the direction of the element of atomic number 10 less.

tion of diminishing mass and diminishing group number by two places. In a β -ray change the element changes its position in the table in the opposite direction by one place. Further, all elements falling into the same place in the periodic table, such as Th, Radio-Th, UrX, and Io, are not merely similar to chemical properties, but are chemically identical, non-separable by chemical methods and probably spectroscopically indistinguishable. The chemical analysis of matter is thus not an ultimate one. It has appeared ultimate hitherto, on account of the impossibility of distinguishing between elements which are chemically identical and non-separable unless these are in the process of change the one into the other. But in that part of the periodic table in which the evolution of the elements is still proceeding as above, each place is seen to be occupied, not by one element, but on the average, for the places occupied at all, by no less than four, the atomic weights of which vary over as much as eight units. This may be true for the rest of the table, and thus each known element may be a group of non-separable elements occupying the same place, the atomic weight not being a real constant, but a mean value of much less fundamental interest than has hitherto been supposed. Although these advances show that matter is even more complex than chemical analysis alone has been able to reveal, they indicate at the same time that the problem of atomic constitution may be more simple than has been supposed from the lack of simple numerical relations between the atomic weights.

E. M.

171. *Properties of Noble Gases.* G. Gehlhoff. (Phys. Zeitschr. 14, pp. 888-841, Sept. 1, 1918).—Describes some simple demonstrations with helium, argon, and neon, made with the aid of coconut charcoal and liquid air, utilising the fact that the charcoal absorbs 280 c.cm. per c.cm. of O, whereas it only absorbs 175 c.cm. of Ar and 15 c.cm. of He. Argon is best shown spectroscopically by absorbing the oxygen with Kr vapour. [Errata, Ibid. p. 1018, Oct. 15, 1918.]

E. E. F.

172. *Thermal Studies on the Transformation of Fusible Alloys in the Solid State.* D. Mazzotto. (R. Accad. Sci. di Modena, 10, p. 405, 1918. N. Cimento, 6, Ser. 6, pp. 81-104, Aug., 1918).—The author has studied the cooling, in an atmosphere of 0° , of a number of alloys either untreated or previously subjected to (1) annealing, the alloy being kept, immediately after solidification, for 0.5-48 hours at a constant temperature lying between the eutectic point and the transformation point; (2) reheating, the alloy being allowed to cool in the ordinary way to the temperature of the air and then heated for 0.5-48 hours at a constant temperature; (3) reheating, preceded by quenching in cold mercury. The method employed is based on the determination of the ratio R_1 between the durations of cooling of the alloy and of mercury through similar intervals of temperature. The normal value, R , of this ratio, that is, its value, provided that the alloy exhibits no evolution of heat owing to change of state or other reason, is determined either by extrapolation of the experimental results or by calculation from the values of the ratio for the constituent metals of the alloy. From $\Delta = R_1 - R$ the amounts of heat evolved in the separate temperature intervals are given in hundredths of a calorie per kg. of alloy by the expression $q = \Delta \cdot 217/P$, where P is the weight of the alloy in gm. and 217 a coefficient depending on the thermal capacity of the crucible filled with mercury. Alloys of the following compositions in parts by weight were examined, but the first four show no exothermal behaviour in the solid condition:

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(1) 1 Tl + 2.7 Bi ; (2) 8 Zn + 2 Sn ; (3) 2 Zn + 8 Sn ; (4) 1 Pb + 1 Bi ; (5) 1 Sn + 1 Bi ; (6) 4 Sn + 1 Bi ; (7) 2 Pb + 1 Sn ; (8) 8 Sn + 2 Tl ; (9) 1 Sn + 1 Cd. Where heat is evolved by the solid alloy, four successive phases are conveniently distinguished : (1) the initial phase, in which the evolution becomes sensible and gradually increases ; (2) the explosive phase, in which the maximal evolution occurs, sometimes accompanied by recalescence ; (3) a diminishing phase ; and (4) a final or vanishing phase. The various thermal treatments described above have a marked influence on the heat of transformation which then varies from 0.99 cal. for alloy (5) to 1.87 cal. for alloy (7). With alloys (5) and (8), which contain the same constituents in different proportions, the heat evolution is at first greater with (5), but after treatment of the alloys is greater with (8). This behaviour is in accord with the hypothesis that the evolution of heat depends on the separation, owing to diminished solubility, of the Bi from the mixed crystals in which it is dissolved. Indeed, according to the equilibrium diagram, alloy (6) should be composed solely of saturated mixed crystals, and should hence exhibit maximal heat evolution ; but after direct cooling it gives only a feeble evolution, since it then contains a large proportion of slightly concentrated crystals, from which only small amounts of Bi separate ; during annealing and reheating, especially if this is preceded by quenching, the alloy is enriched with saturated crystals and the heat evolution approaches the max. value corresponding with the condition of perfect equilibrium. Similar explanations hold with the other alloys. When, however, the latter contain tin, which undergoes an allotropic transformation at about 161° , the diminution in solubility is attributable partly to the lowering of the temperature, and partly to the diminished solvent and dissolving power of the modification stable below 161° .

T. H. P.

173. *Method of Disintegrating Metals and their Oxides into a Colloidal State.* **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 211-218, May, 1918.)—When a piece of metal heated in a Bunsen burner or by an electric current is suddenly introduced into water, it undergoes disintegration to some extent, yielding ultramicroscopic particles, which, in most cases, travel partly towards the cathode and partly towards the anode. Oxides or hydroxides of metals also form similar particles, the majority of these migrating towards the cathode.

T. H. P.

174. *Nature of the Double Layer in Colloidal Particles.* **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 201-209, May, 1918.)—J. J. Thomson's theory (Phil. Mag. 86. p. 820, 1898) affords a good explanation of the dissociation of substances when these are brought together, but is not able to explain the formation of the electric double layer at the surface of separation between two bodies. The complete separation of the dissociated charges is explained in two ways : as due either to the specific action of the dissociated ions or to the specific attraction of the medium on the dissociated ions. If these two views are adopted, the formation of the double layers may be regarded as follows : When a metallic hydroxide, which is a positive colloid, is placed in water, it is slightly dissociated into positive metal ions and hydroxyl ions owing to the dissociating power of water with its high dielectric constant. On account of their osmotic pressures, ions of both kinds diffuse, but the hydroxyl ions have the greater velocity, and hence proceed the further into the water, a partial separation of the ions thus taking place. When this stage is once reached the attraction of the positive ions prevents further

diffusion of the hydroxyl ions. Thus the double layers are formed, the positive coatings being in the case of a positive colloid on the surfaces of the colloidal particles and the negative ones on the water side of the surfaces of separation. There is also evidence indicating some interaction between the ions and the medium; for instance, Wilson's experiments [Abstract No. 1025 (1900)] and the reduction of the velocity of ions in dry gases by a trace of water-vapour, an effect especially marked with negative ions [see Zeleny, Abstract No. 1919 (1901)]. Analogous explanations may be applied to the formation of the double layer with a negative colloid and to the influence of an electrolyte or of a non-electrolyte on the stability of colloidal solutions.

T. H. P.

175. Corrosion of Metals covered with a Thin Layer of Water or an Alcohol and subjected to the Action of Ultra-violet Rays. **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 253-260, May, 1913.)—Although Svedberg [Abstract No. 1201 (1910)] regards the disintegrating action of ultra-violet rays on the surface of a metal immersed in water or an alcohol as a secondary effect of the rays, the results of Lenard and Wolf [Wied. Ann. 87. p. 448, 1889] and of H. Rubens and E. Ladenburg [Abstract No. 446 (1908)] suggest that the rays exert a direct action in this respect. The author has repeated Svedberg's experiments and has also investigated the cataphoresis of the colloidal particles formed as a result of the disintegration of the metals. It was found that some of the particles travel in the direction of the current and others in the opposite direction, showing that the colloidal particles are of the metal and its hydroxide. The surface of the metal was observed to be corroded, and investigation showed that the etching action of the rays is favoured more by the presence of water than by that of air or oxygen. In the former case the action is due partly to hydrogen peroxide, and in the latter partly to ozone, but the phenomena observed are not completely explainable in this way. The author regards these phenomena as closely connected with photo-electric phenomena and explains them as follows :—A metal placed in water dissolves slightly in the form of positive ions owing to their solution tension, so that a double layer is formed on its surface, the positive ions of metal lying on the outer coating. The influence of ultra-violet rays on such a surface causes the electrons in the inner coating of the double layer to fly out and unite with positive metal ions in the outer coating. This union transforms positive ions into free neutral atoms, which separate from the metal. At this stage some of the atoms act on the surrounding water with formation of hydroxide, whilst others give molecules of the metal. If the double layer is destroyed in this way another portion of metal dissolves in the form of positive ions, a double layer being again formed and subsequently destroyed by the action of the rays, and so on. These processes continue so long as illumination with the ultra-violet rays persists. If this explanation is correct, antimony should exhibit greater resistance to the action of the rays than cadmium, and this is actually found to be the case.

T. H. P.

176. Passage of Nascent Hydrogen through Iron. **M. Bellati and S. Lussana.** (N. Cimento, 5. Ser. 6. pp. 889-892, May, 1913.)—The results recently published by Charpy and Bonnerot [see Abstract No. 1121 (1912)] confirm those obtained by the authors (R. Istituto Veneto Atti, 1888-1891).

T. H. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1914.

GENERAL PHYSICS.

177. *Transit Micrometer with Personal Equation.* A. Claude and L. Driencourt. (Comptes Rendus, 157. pp. 685-687, Oct. 27, 1913.)—One of the chief difficulties in observations of star transits for time determination is the personal equation involved in the estimation of fractions of the interval between successive beats of the clock or chronometer. The authors propose to eliminate this by a special form of reticule in which the distances between the threads may be changed so that for any star the interval between the threads may correspond exactly to the interval between the beats of the clock. This is done by the reticule frame being in the form of a hinged rectangular frame, the motion being controlled by a graduated screw. When the frame is square on, the intervals are adjusted to be correct on an equatorial star; for other stars the rectangle is converted into a rhombic figure depending on the declination of the star, thus diminishing the distance between the threads so that they still correspond to the same interval of time.

C. P. B.

178. *The Kilowatt as the Unit of Power in the Metric System.* G. Darrieus. (Lumière Électr. 24. pp. 886-887, Dec. 18, 1913.)—The author points out the many advantages that accrue from adopting the kilogramme as the standard of mass, and the metre as the unit of length. The unit of force, for example, would be the force that would have to be applied to the mass of 1 kg. in order to give it an acceleration of 1 m. per sec. per sec. It would therefore equal 10^4 dynes. The suggestion has been made that this unit be called the *cop*, from Copernicus. The unit of work in this system would be $10^4 \times 10^2$, that is, 10^7 ergs or the joule. The unit of power also would be the watt. Numerical examples are given to show how engineering calculations would be very appreciably simplified if we adopt the metre-kilogramme-second system.

A. R.

179. *Kilogramme Force and Kilogramme Mass.* A. Berger. (Zeitschr. Vereines Deutsch. Ing. 57. pp. 1628-1634, Oct. 11, 1913.)—A controversial
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discussion of Mass, Inertia, Weight, and Quantity of Matter. Points out certain advantages of a cm.-force unit-second system, and proposes the kg. weight as a unit of force. E. Budde points out that in Germany the kilogramme is already, by law, a unit of mass. A. D.

180. *Validity of Stokes' Law for Small Drops of Liquid moving in a Liquid.* I. Nordlund. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 18. pp. 1-18, 1918.)—Describes two series of experiments undertaken to examine the validity of Stokes' law (and of some corrections that have been applied to it, notably by Rybczynski and Hadamard) in the case of small drops of liquid moving in a liquid medium. The first series, of 69 experiments, was made with drops of nitrobenzol falling in water already saturated with nitrobenzol, the diam. of the drops being measured directly by means of a microscope. The rate of fall was found to be 1 % higher than was to be expected from Stokes' law (as modified by Ladenburg). This was found to be due to the rapid loss of saturation of the solution employed, even when the temperature remained constant. Hence a second series of 105 experiments was made with drops of Hg falling in a mixture of glycerine and water. In this case the difference was only 0.076 %. In both results Rybczynski's modification would have introduced an enormously greater discrepancy. Hence it appears that the Stokes-Ladenburg law holds rigorously for the cases investigated, and that it is therefore legitimate to apply Einstein's formula to the Brownian movement of liquid drops in a liquid medium. The author promises the results of his experimental determinations, made by this method, of Avogadro's constant.

J. W. T. W.

181. *Forces Acting on a Solid Sphere in Contact with a Liquid Surface* A. Ferguson. (Phil. Mag. 26. pp. 925-984, Nov., 1918.)—Introduces a closer approximation into the equation giving the force required to detach a circular disc from the surface of a liquid. The angle of contact of the liquid along an edge is, however, very uncertain, and hence the author discusses the case of a sphere of large radius substituted for the disc and suspended so that its lowest point is exactly level with the general surface of the liquid. He deduces, by the method of successive approximations, an equation for this case, giving, when the contact angle is zero, the force required to maintain the sphere in this position. He uses a glass sphere so suspended to determine experimentally the surface tensions of benzene, alcohol, and water, and obtains exceedingly consistent results. J. W. T. W.

182. *Observation of Brownian Movements.* F. Bourrières. (Comptes Rendus, 157. pp. 1416-1417, Dec. 22, 1918.)—A method is described of observing Brownian movements with magnification greater than 20,000. In place of the ordinary ocular of a microscope is placed a second complete microscope, giving an arrangement of very great magnifying power. A Zeiss objective DD was used in the first microscope, having a magnifying power of about 50. The microscope replacing the ocular of the first gave a magnification of 400, so that the total magnification was about 20,000. The ultramicroscopic illumination was given by a simple Nernst lamp with the arrangement of Cotton and Mouton. A colloidal solution of silver was prepared with special care and on investigation with the above arrangement the Brownian motion appeared to be composed of two movements: the first, with amplitude of the order of 1μ , rather sharp, but very smooth and

elastic, occupying all the field; the second, with amplitude of the order of 0.02μ , of a lively vibratory nature. In practice it is advisable to pass gradually to the enormous magnifications obtainable by this method.

A. W.

183. *Turbulent Flow of Water and Mercury through Capillary Tubes.* G. Lechner. (Ann. d. Physik, 42. 8. pp. 614-642, Oct. 16, 1918. Extract of Dissertation, Würzburg.)—Describes research on the effect which capillary tubes of spiral form have in starting turbulent flow, and also deals with the effect of altering the radius of the capillary. The results show that as the number of coils of the spiral capillary increases the turbulence also increases, and the Reynolds criterion for the critical velocity does not in general hold good. The critical velocity is changed to smaller values, and the change is greater the greater the radius of the capillary is. Observations with coloured fluids show that with increasing velocity the turbulence passes from the last coil of the spiral to those in front. For a straight tube with smooth walls a definite turbulence, measured by the resistance which the tube offers to the passage of the fluid, always corresponds to a given velocity; for a spiral tube this resistance is always greater. If Q is the quantity of liquid flowing through the tube per sec., P the pressure, then $Q = P/w$, where the resistance w only remains constant as long as Poiseuille's law holds good. By increasing the velocity a constant, but larger, resistance is again reached, when $Q - Q_0 = P/w$. Q_0 decreases with the number of coils, while $w = dQ/dP$, and so is independent of the number of coils and also of the velocity. Finally $Q_0 = 0$, and thus Poiseuille's law $Q = P/w$ again holds.

A. W.

184. *Region in which Stokes' Resistance Formula is Valid.* C. W. Oseen. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 16. pp. 1-15, 1918.)—Determines an additional term to Stokes' formula to allow for the vortex motion.

E. H. B.

185. *The Weight of a Falling Drop and the Laws of Tate.* XII. *Drop-weights of Certain Organic Liquids and the Surface Tensions and Capillary Constants calculated from them.* J. L. R. Morgan and E. C. Stone. (Amer. Chem. Soc., Journ. 85. pp. 1505-1524, Oct., 1918.)—The authors have determined the drop-weights in the case of twenty-two liquids and have calculated therefrom the value of the surface tension, the results obtained being as follows:—

Substance.	γ .	Substance.	γ .
Methyl propyl ketone	25.976-0.1026t	Isovaleric acid	26.253-0.0844t
Paraldehyde	27.686-0.1110t	o-Toluidine	41.867-0.1139t
Ethyl nitrate	29.668-0.1239t	p-Toluidine	38.277-0.0924t
Nitro-methane	38.534-0.1423t	Formamide	58.306-0.7927t
Butyl alcohol	25.348-0.0788t	Dimethyl nitroso-amine	39.639-0.1216t
Isobutyl alcohol	23.569-0.025t	Acetophenone	40.805-0.1162t
Allyl alcohol	26.499-0.0864t	Benzophenone	45.669-0.1076t
Formic acid	38.368-0.1025t	Ethylpropyl ether	20.365-0.1079t
Propionic acid	27.797-0.1067t+0.000183t ²	Acetal	44.341-0.1231t
Butyric acid	26.762-0.0981t+0.000104t ²	Anethole	36.871-0.1016t
Isobutyric acid	26.206-0.0986t		

Of the above liquids only three, acetal, ethyl propyl ether, and o-toluidine, have normal molecular weight according to the Morgan definition, i.e. only these yield the same value for the critical temperature independent of the temperature of observation. Benzophenone was studied as much as 89°

below its melting-point in order to see if the super-cooled liquid showed any abnormalities ; but none were observed. The observations previously made that the ortho-compound has always the highest surface tension, while the para-compound has the lowest, is confirmed by the toluidines. A. F.

186. *The Weight of a Falling Drop and the Laws of Tate.* XIII. *Drop-weights of Aqueous Solutions and the Surface Tensions calculated from them.* J. L. R. Morgan and G. A. Bole. (Amer. Chem. Soc., Journ. 85. pp. 1750-1759, Nov., 1918.)—In continuation of previous work [see preceding Abstract] the authors have studied the drop-weights and surface tensions of thirty semi-normal solutions. The change in surface tension with temperature was found to be linear. Some salts were found to increase the surface tension of water and some to diminish it, so that the generalisation of Valson that all normal solutions at the same temperature have identical values of surface tension becomes untenable. The acids, citric, tartaric, and oxalic, lower the surface tension of water, so that hydrolysis in the case of such salts would tend to lower the surface tension. For the most part, salts of the same acid show a marked agreement in their values for the surface tension at the same temperatures, but there are also decided exceptions to this generalisation. The surface tension of a solution of two salts, one of which raises the surface tension and the other lowers it, is an additive property of the two separate solutions, provided no chemical reaction takes place between them and the values for the two are not very far removed from the value for water. If one of the solutes causes much larger effect than the other, the value for the mixture lies closer to the one with the greater effect. A. F.

187. *"Suction" between Passing Vessels.* A. H. Gibson and J. H. Thompson. (Inst. of Naval Architects, Trans. 55. 2. pp. 61-78 ; Discussion, pp. 74-75, 1918. Engineer, 116. pp. 22-24, July 4, 1918.)—A more complete account of the work dealt with in Abstract No. 1617 (1912).

188. *On the Criterion for the Occurrence of Cavitation.* L. Gümbel. (Inst. of Naval Architects, Trans. 55. 2. pp. 118-123 ; Correspondence, pp. 124-186, 1918. Engineering, 96. pp. 76-77, July 18, 1918.)

189. *Variability of the Velocity of Ascent of Registering and Pilot Balloons.* R. Dietzius. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 548-605, March, 1918.)—Besides vertical currents there are a number of causes which make the velocities of ascent of pilot and registering balloons variable. Some of the causes vary gradually with the rates of ascent and are therefore of little importance, others, such as the varying difference of temperature between the gas in the balloon and the free air outside, produce considerable fluctuations in the rate. With registering balloons, the rate of ascent is much more subject to disturbance than with pilot balloons and this result is confirmed by observation. The determination of the rate of ascent of a given balloon at a given height assuming absence of vertical currents, and of the magnitudes of the vertical currents by a comparison of the observed and computed rates of ascent is a more complicated problem than is often considered to be the case. R. C.

190. *On the Relation between the Cloudiness of the Sky and the Duration of Sunshine.* J. P. van der Stok. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 507-521, Dec. 27, 1918.)—A mean value for the proportion of the

sky which is covered by clouds may be arrived at in two ways : (1) from the recorded percentage of the possible duration of sunshine, and (2) from normal estimates of cloud amounts. Both these methods are rendered inaccurate by the fact that clouds are not horizontal laminæ but have vertical depth, so that clouds near the horizon appear to cover more of the sky than their horizontal area warrants. If the sun were in the zenith obviously the method (1) would be free from this source of error, and summer observations will be less affected than winter ones by it. From a comparison of the results obtained by the two methods at certain stations in Holland the author attempts to determine the mean ratio of vertical depth to horizontal diameter of clouds.

J. S. DI.

191. *On Interference Colours in Clouds.* R. H. Goddard. (Science, 89, pp. 881-882, Dec. 19, 1918.)—The author has noticed that often by careful observation faint tints may be observed on clouds about 15° from the sun. The colours are usually red or green ; they appear in irregular patches and are totally different from rainbow effects. In the paper it is suggested that the colours are due to interference produced by a thin cloud of small water-drops of homogeneous size, the colour effect being the same as that produced by a soap film.

J. S. DI.

192. *Wolf Sun-spot Numbers, 1901-1912.* A. Wolfer. (Mount Weather Observatory, Bull. 5, pp. 365-368, 1918.)—In continuation of the series of Wolf sun-spot numbers published for the period 1749-1900, new tables are given by Wolfer, of Zurich, showing the sun-spot numbers on the same system for the period 1901-1912. Both observed and smoothed values are tabulated. The period indicated is 11.111 years.

C. P. B.

193. *Harmonic Analysis of Sun-spot Cycle.* A. A. Michelson. (Astrophys. Journ. 88, pp. 268-274, Oct., 1918.)—By means of mechanical integration with the harmonic analyser [Abstract No. 241 (1898)] the values of the coefficients of a Fourier series may be obtained with ease and considerable accuracy. The given function is copied on the machine, which then draws a curve whose ordinates at given distances along the axis of abscissæ are proportional to the coefficients of the corresponding Fourier series. A table is given showing the periodicities determined from such analysis of the sun-spot curve from 1750 to 1910. The curves as given do not extend beyond the 6-year period, but in another case they have been extended to something less than the 8-year period, with no certain indications of anything like a period of 8.86 years, or of 4.79 years. It would appear that with the exception of the 11-year period, and possibly another of the order of 100 years' the many periods found by previous investigators are illusory.

C. P. B.

194. *Radial Motion in Sun-spots.* C. E. St. John. (Observatory, No. 466, pp. 895-897, Oct., 1918. Paper read before the British Assoc. at Birmingham.)—Observations of sun-spot spectra, for the investigation of the radial motion found by Evershed in 1909, were commenced in 1910 with the powerful 60-ft. tower equipment at Mount Wilson. Some 500 lines were specially examined, representing a wide range of intensity and belonging to 26 different elements. The most striking feature of the results is the systematic dependence of the displacements, in amount and sign, upon the intensities of the lines, and their variation with wave-length in the case of lines of the same solar intensity. In one important point these results differ from those obtained by Evershed, in VOL. XVII.—A.—1914.

that the displacements do not disappear abruptly at the outer boundary of the penumbra, but gradually fade away. The observed displacements vary from 2.04 km. per sec. for lines of intensity 00 to 0.24 km. per sec. for lines of intensity 10, and indicate an outflow of the vapours from sun-spots, tangential to the solar surface. The displacements are not equal for lines of equal intensity of all elements, and this points to differences of level. C. P. B.

195. *The General Magnetic Field of the Sun.* H. Deslandres. (Comptes Rendus, 157. pp. 517-524, Oct. 6, 1918.)—The author reviews the various papers published by himself and others in which the idea of the sun's general magnetic field has been developed, extending over the period 1896-1918. He regards the phenomena of prominences and coronal streamers as explainable by the action of the field on streams of charged ions, the deduced strength of field being of the same order as that observed. The field strength at the base of the solar atmosphere is probably much greater than at the outer boundaries. C. P. B.

196. *Spectrum of Comet Melcalif (1918b).* J. Bosler. (Comptes Rendus, 157. p. 589, Oct. 6, 1918.)—Three photographs of the spectrum of this comet were obtained at Meudon with an objective-prism camera, 0.25 m. aperture and focal length 0.75 m. on 1918 Sept. 24, 25, 26. Exposures varied from 2h. 28m. to 8h. 80m. The spectrum shows a faint continuous band, with three sharp condensations near $\lambda 478$, $\lambda 407$, and $\lambda 888$, closely resembling the spectrum of Comet Schaumasse. [See Abstract No. 1802 (1918).] C. P. B.

197. *Photographic Magnitudes of Selected Stars.* C. H. Gingrich. (Astrophys. Journ. 88. pp. 209-240, Oct., 1918.)—In the series of charts of variable stars published by Hagen comparison stars are provided over a region one degree square, with each variable at the centre. The magnitudes of these comparison stars are visual, being finally checked with the 12-in. equatorial of the Georgetown College Observatory, Washington, D.C. As so much of modern observing is done photographically, and the photographic and visual magnitudes of stars are in general somewhat different, depending on colour, etc., the present investigation was undertaken at the Yerkes Observatory with the object of providing comparison photographic magnitudes for certain of the Hagen charts. Tables are then given showing the visual and photographic magnitudes for several of the Hagen star fields, with a sample photograph showing the stars surrounding the variable S Cygni, taken with the 24-in. reflector. C. P. B.

198. *Photographic Magnitude Scale of North Polar Sequence.* F. H. Seares. (Astrophys. Journ. 88. pp. 241-267, Oct., 1918. Contribution from Mt. Wilson Solar Observatory No. 70.)—Photographic magnitudes of the bright stars of the Polar Sequence have been determined by comparison with the stars included between magnitudes 10.5 and 15.5. Reduction in the light was produced by combinations of screens and diaphragms whose absorption constants range from one to eleven magnitudes. The Harvard magnitudes for the faint stars were used for the comparison. Various tests indicate that a mean scale has been determined which is nearly homogeneous with that of the faint stars. A direct intercomparison of *Polaris* and two other bright stars having magnitudes 5.99 and 7.78, gave differences in brightness practically identical with those resulting from the mean scale. Comparisons of the mean scale for bright stars with the corresponding Harvard values shows a
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marked divergence, nearly linear in character, the observed differences being zero at the tenth magnitude. A comparison of the mean scale with the determinations of Schwarzschild and Parkhurst, extending from magnitudes 4.0 to 7.5, gives sensibly constant differences which become zero when the Mt. Wilson magnitudes are referred to the international zero point. C. P. B.

199. *Parallax of North America Nebula.* E. B. Andersen. (Astrophys. Journ. 88. pp. 275-281, Oct., 1918.)—In general all that can be said with any certainty concerning parallaxes of nebulae is that the gaseous nebulae do not differ from the fixed stars in regard to either proper motion or parallax. Apart from the ordinary physical connection between nebulae and stars, of which several are known (Pleiades, Orion, Lyra, etc.), the vast irregular gaseous nebulae often seem to have a peculiar influence on the stars in their vicinity; their density may suddenly decrease to such a degree that it looks as if the nebula were placed in a dark hole. Characteristic examples of this type are Orion, ρ Ophiuchi, ξ Persei, North America, γ Scuti, 15 Monocerotis, etc. It is to be noted that all these objects are in regions very rich in stars. Whatever the conditions may be in the "rifts" traversing these rich regions, it is evident that the stars which are between the earth and the nebula must be unaffected. By taking account of the star-density and parallaxes in the vicinity of these nebulae it may therefore be possible to obtain an approximate idea of the distance of the nebula itself. In the present case this is done for the North America nebula, the result being that its parallax is indicated as being nearly equal to that of stars of 8.5 magnitude, which, leaving proper motion out of consideration, has the probable value of 0.007". C. P. B.

200. *Giant and Dwarf Stars.* H. N. Russell. (Observatory, No. 464. pp. 824-829, Aug., 1918. Paper read before the Royal Astronomical Society, June, 1918.)—Starting with the comparison of brightness and spectrum, it is shown that there do not appear to be any faint white stars. All the faint stars are at least as red as class K; most of them are K5 or M; all of the stars of classes A or B, especially the latter, seem to be many times brighter than the sun. On the other hand, the converse is not true; there seems no doubt that there exist many very bright red stars, Arcturus, Aldebaran, Antares, etc. Taking the reddest stars (classes K and M), they are divisible into two groups, one containing very bright stars, the other containing stars diminishing rapidly in brightness with increasing redness. The stars of class B may be regarded as belonging to either series, and the two groups intermingle for class A and are probably not really separated in class F. These different series of stars were first noticed by Hertzsprung, and were designated by him "giant" and "dwarf" stars. It would thus appear that the absolute mass of any star may be regarded as a function of its mass density, and surface brightness. It is concluded that the differences between the giant and dwarf stars do not arise from differences of mass. C. P. B.

201. *Fundamental Star-places.* R. Trümpler. (Gesell. Wiss Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 249-285, 1918.)—A full description is given of the method of determining fundamental star-places, with examples of the system of reduction of the observations. C. P. B.

LIGHT.

202. Medial-telescope of Short Focus. L. Schupmann. (*Zeitschr. Instrumentenk.* 88. pp. 808-812, Oct., 1918.)—A description is given, with sketches showing the disposition of the various parts, of a short-focus type of telescope of special design, called the medial-telescope. The chief characteristic is the combination of lens and mirror systems for shortening length of body and correcting certain of the aberrations. C. P. B.

203. Grating Spectrograph for Radial Velocities. M. Hamy. (*Comptes Rendus*, 157. pp. 666-671, Oct. 27, 1918.)—An interesting modification of grating spectroscope is described, the chief necessity being a diffraction grating giving two spectra of nearly equal intensity. A single collimator is employed, normal to the grating, and for stellar spectra no slit would be needed, thereby rendering it possible to photograph the spectra of several stars at the same time. C. P. B.

204. Chromatic Aberration of Telescope Objectives. H. Fassbender and A. Wethauer. (*Zeitschr. Instrumentenk.* 88. pp. 265-277, Sept., 1918. Communication from the Physikal.-Techn. Reichsanstalt.)—Tables are given of the variations in focal length for light of selected wave-lengths from red to blue, for several of the large objectives of national observatories, and for several types of spectroscopic objective. The results are also presented as curves showing the differences of focus in mm. for different portions of the spectrum. C. P. B.

205. Determination of Zonal Variation of Equivalent Focus. E. D. Tillyer. (*Washington Acad. Sci., Journ.* 8. pp. 481-484, Dec. 4, 1918.)—Hartmann's method of lens-testing is laborious when applied to zonal variations. The present author proposes a method for finding both the variations of the position of the focus and of the equivalent focal length from one set of measures. By making several sets in light of different wave-lengths, the axial and oblique aberrations can also be obtained. A nearly parallel beam of light from a distant monochromatic source falls upon a metal plate pierced with holes of 1 mm. diam., arranged in a line at about 8-mm. intervals. The rays through the holes are then refracted through the lens system to be tested. A shadow photograph is taken upon a plate placed close to the lens, a second at a considerable distance on the other side of the focus. The shadowgraphs are measured on a small Zeiss comparator. If a ray passing through a hole distant h from the axis meets the two plates at distances a and b from the axis, and cuts the axis at distance v from the first plate, we have $v = ad/(a + b)$, d being the interval between the plates. For an object at infinity, we have $E = h/\sin u$, where E is the equivalent focal length, h the distance from the axis of the entering ray, and u is the angle this ray makes with the axis after refraction. The length h is read off on the metal plate; the angle u can be obtained from $\tan u = (a + b)/d = a/v$, and consequently E and $\Delta E = \Delta v$. A. E.

206. Achromatism and Anastigmatism in Photographic Doublet. H. C. Lord. (*Astrophys. Journ.* 88. pp. 297-300, Oct., 1918.)—In the course of VOL. XVII.—A.—1914.

applying Taylor's method of discussing aberrations of lens systems to the type of photographic objective consisting of four separated thin lenses arranged in the form of a symmetrical doublet, a simple relation was discovered, which must be satisfied if the objective is to be as free as possible from chromatic and astigmatic errors. This may be stated thus :—"The separation between the positive and negative lens minus the focal length of the negative lens must equal the focal length of the positive lens multiplied by the square root of the ratio of the indices of refraction divided by the ratio of the dispersive powers." An analytical proof is given of the proposition, based on Taylor's formula. C. P. B.

207. *Reflection from Fluids in Ultra-red.* A. K. Angström. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 26. pp. 1-28, 1918.)—The following substances were dealt with: Water, ethyl alcohol, methyl alcohol, benzol, toluol; and the investigation was carried out for the spectral region 1 to 6 μ . From a knowledge of the reflecting power of the different substances the index of refraction for different wave-lengths was calculated from Cauchy's formula. Reflection maxima were found for the wave-lengths given in the following table :—

	λ
Water.....	8·20, (1·95), (4·5)
Ethyl alcohol	8·10, (4·5)
Methyl alcohol.....	8·14, (4·5)
Benzol	8·00, 8·70
Toluol	8·00, 8·70

The values in brackets indicate maxima not so well defined as the others, which, as shown by the curves reproduced, are all fairly sharp. A. W.

208. *Selective Radiation from Various Substances.* W. W. Coblentz. (Bureau of Standards, Bull. 9. pp. 81-117, March 15, 1913.)—In previous papers the author investigated the most important so-called constant, α , of spectral radiation of various metals, and it was found that the supposed constant had a temperature coefficient. This variability of α was subsequently explained by noting the fact that if the reflecting power (and hence the absorptivity) were uniform throughout the whole spectrum, the emission would be that of a "grey body." Hence the position of the max. emission λ_{\max} should shift uniformly with rise of temperature toward the shorter wave-lengths and the intensity of the max. emission should increase according to the equation, $E_{\max} = BT^{\alpha}$. But the reflecting power of metals has a temperature coefficient marked in the infra-red and decreasing to a negligible quantity at 8 μ to 4 μ . Moreover, the reflecting power of metals is low in the visible spectrum, and increases rapidly to a fairly constant value beyond 8 μ . It results that the value of E_{\max} is larger than it would be if the reflecting power at 1·2 μ (where reflecting power decreases at low temperatures, but at high temperatures λ_{\max} is in the region of 1·2 μ) were the same as at 8 μ , and consequently the value of α decreases with rise in temperatures [see Abstracts Nos. 672 (1910), 927 (1911), and 142 (1912)]. In a new series of investigations, without expecting to determine a radiation constant, α , the author has endeavoured to determine a series of spectral energy curves and also some temperature coefficients. Mendenhall's method, which is based on the proved result that the temperature determined by sighting an optical pyrometer into a V-shaped fold in a strip of metal is closely the true tem-

perature of the metal, was employed. The spectrum energy curves were determined by means of a vacuum bolometer, mirror spectrometer, and a fluorite prism: the bolometer strip being 0.6 mm. wide and subtending an angle of 4'. Besides a series of 12 energy curves was obtained, in which the temperatures were measured by means of a potentiometer and an Heraeus thermo-couple, of wires 0.1 mm. in diam. The results are embodied in a complete set of curves and tables.

II. *Emission Spectra of Neon, Helium, and Mercury.*—The spectral-energy distribution of the radiation from various gases in vacuum tubes was given in a previous paper. The most intense lines were found to lie just beyond the red; and in the region 1.5μ to 3.5μ there was a complex radiation, weak in intensity and usually unresolved with the spectrometric apparatus employed. Subsequent experimenters have succeeded in resolving this latter region into separate lines. The results hitherto may be summarised by stating that in spark spectra the most intense lines are situated in the ultra-violet; that in arc and vacuum-tube spectra the most intense lines are situated just beyond the red; and that in the spectra of solids the max. emission lies far in the infra-red but shifts rapidly toward the visible with rise in temperature. From the prismatic and the normal spectral energy curves of neon taken with the present spectro-bolometric apparatus it is seen that the max. emission lies within the group of lines in the red of which the line at 0.64μ is the brightest to the eye. The intensity of the group of lines in the region of 0.8μ is only about $\frac{1}{10}$ th that of the red. The spectrum of helium consists of fewer lines than that of neon, the most prominent one (visually) being the yellow line at 0.5876μ . Radiometrically, however, conditions are quite different. The red lines are then found to be as intense as the yellow line. The most intense line lies at 1.088μ . The luminous efficiency of vacuum-tube radiation (air, N, CO_2 , He, etc.) is of the order of 15 to 20 per cent., or perhaps even much lower owing to the great amount of infra-red radiations emitted. In marked contrast with these is neon, in which the infra-red is almost entirely absent, so that its luminous efficiency is of the order of 80 to 90 per cent. The colour of this light is a rich crimson.

The spectrum of neon is composed of numerous fine lines, more than 60 of which lie between the red and yellow He-lines (0.5876μ and 0.7065μ). There is sufficient reason for believing that the emission lines in Ne are just as numerous at 0.8μ to 1.0μ as they are in the visible spectrum, so that whatever the dispersion the same energy distribution will obtain as here observed, viz. that the strongest lines occur in the region 0.6μ to 0.7μ of the visible spectrum. In this respect neon is unique.

III. *Emissivity of Different Parts of an Acetylene Flame.*—Previously it has been shown that in the spectral energy curve of an acetylene flame viewed flatwise the max. emission at 1.25μ is twice the height of the maximum at 4.85μ ; and that for the flame viewed edgewise the ratio is 5.5. In the visible spectrum the spectral energy curves of the flame viewed flatwise and edgewise were found to be superposable as is to be expected, for the colour of the flame appears to be independent of the thickness of the radiating layer. The relative intensities of the two maxima found in different regions of the acetylene flame (carbon particles and CO_2) were investigated. A flat and cylindrical flame were observed. In the former the carbon particles have their max. emission 2 cm. above the base, while the CO_2 emission continues very strong several cm. above the luminous flame. On examining the radiation from the cylindrical flame it was observed that at the base where combustion begins, but where the flame is almost non-luminous, the CO_2

[CO?] already emits a considerable amount of energy. The carbon particles emit but little in the hazy region 2 cm. above the base. The CO₂ emission continues strong for some distance above the luminous part of the flame.

IV. *Variation of Emissivity with Thickness of the Radiating Layer—Oxides.*—The glowers used in the experiments were squirted and baked by the Westinghouse Nernst Lamp Co. and were seasoned by operating them at a high temperature for 5 or 6 hours. The generator (rotary converter) was operated on a storage battery to ensure a constant voltage. Alternating current was used so that no transference of Pt from the terminals into the glowers occurred. Experiments were made on the shape of the spectral energy curves as modified by the change in thickness of the radiating layer. This gives the loss in efficiency resulting from the preponderating increase in emission in the infra-red spectrum. The results show that for the thin glowers the spectral energy curves superpose over practically the whole length of the curve. The increase in the emissivity extending from 1.5μ to 6μ is very marked in the curves obtained. In order to obtain the same emissivity in the visible spectrum the thickest filament radiates 18.4 per cent. more infra-red energy than obtains in the thinnest filament. The commercial alternating-current glower is a hollow cylinder which is more efficient than a solid glower of the same diam. To manufacturers it is well known that the very thin glowers are the most efficient. The data previously given on the Welsbach mantle and those given in the present paper on the emissivity of various solid glowers show why this is the case. The thicker the glower the more nearly its radiation approaches that of a black body. For the thinnest glower the max. emission lies at about $\lambda_{\text{max.}} = 1.25\mu$, and for the thickest filament the max. emission is at about $\lambda_{\text{max.}} = 1.82\mu$, although it is at the same emissivity in the visible. The data given confirm the previous conclusions that the radiation constant, α , of the Nernst glower varies with the thickness of the radiating layer. In the paper the results of experiments are also given on: V. *Radiation from a uniformly heated cavity and from its enclosing walls*, and on: VI. *Standard spectral energy curves*. These are exhibited in tables and curves. A note is given on *Light-filters which absorb all the infra-red*. The results obtained may be summarised by stating that the method of obtaining monochromatic radiation by means of filters is very inefficient when concentrated solutions must be employed. Thus the 8 per cent. solution transmits 58 per cent. and the 8.5 per cent. solution transmits only 55 per cent. at 0.589μ , the transmission being much higher in the blue and in the green. *The transmission of prism material* was also investigated. A plate of quartz 1.8 cm. in thickness was found to increase rapidly in opacity beyond 1.2μ ; so that it is an unsuitable material for spectral energy work at wave-lengths above this. The same is true of crown glass. A sample of deep green fluorite showed numerous absorption bands.

J. J. S.

209. *Efficiency of Selenium as a Detector of Light.* E. E. Fournier d'Albe. (Roy. Soc., Proc. Ser. A. 89. pp. 75–90, Aug. 19, 1918.)—Investigation was made as to the limits up to which minute quantities of light and minute variations of its intensity may be discovered by means of selenium. Two actions of light may be used: (1) A change in the conductivity of Se, and (2) the generation of an e.m.f. in a voltaic cell in which Se is an electrode. The efficiency of an apparatus for the detection of light is the ratio of the amount of measurable effect it indicates to the amount of light received by the apparatus. The amount of light available is best stated in terms of the

lumen. Se "cells," properly so called, are electrolytic cells in which illuminated Se forms one of the electrodes and generates an e.m.f. Their efficiency is the e.m.f. in volts generated per lumen when the illumination is 1 lux (*i.e.* 1 candle-metre); the lumen being the amount of light falling on 1 sq. m. distant 1 m. from a source of 1 c.p. Se "cells" in which the action due to light is a change in resistance are more properly termed Se "bridges," and the "galvanometric efficiency" may be defined as the increase of conductivity produced in them by unit flux of light. Stebbins has recently studied the light curve of Algol by means of a selenium bridge. The following conditions are proposed for determining the normal galvanometric efficiency of a selenium bridge: (a) Quality of light: complete radiation from a standard pentane lamp; (b) Illumination: 1 lux; (c) Voltage: 1 volt; (d) Temperature: 16° C.; (e) History: alternate light and darkness for one minute each until steady state is attained; (f) Measurement: readings for successive minutes during recovery. Evaluation of the "normal galvanometric efficiency" in micromhos per lumen, in this case equivalent to microamps. per lumen, or microamps. per sq. cm. of sensitive surface, divided by 0.0001. After a preliminary experiment to test the efficiency of Se as a detector of small fluxes of light, observations were made with a Dolezalek quadrant electrometer. The galvanometric efficiency was of the order of 300 micromhos per lumen. The best results were got with a Kelvin differential galvanometer. Comparisons were made with a potassium photo-electric cell and with the human eye. In testing minute quantities of light the minimum illumination reached was 10 microlux. The law of light action was investigated and was found to be a square-root law down to the feeblest illuminations. The theoretical limit of light action discoverable by means of present-day methods and apparatus was calculated, and shown to be very far beyond the power of the eye when Se is used. Thus there is given a means of deciding the question of the discrete structure of radiant energy (theory of quanta). The author shows theoretically and experimentally that Se apparatus is capable of discriminating differences and variations of luminosity quite inappreciable by the eye.

J. J. S.

210. *Correcting Colour Sensitiveness of Photographic Plates.* H. Morris-Airey and S. H. Long. (Univ. of Durham Phil. Soc., Proc. 5. pp. 119-120, 1912-1913.)—A method is described for equalising the photographic action of the various spectral colours on colour-sensitised plates, as even the best of these do not show an equal action throughout the range from red to violet. To some extent this may be done by the introduction of carefully selected colour-filters, but it is thought that none of these compensate the plates sufficiently for absorption spectra investigations. The author uses a screen prepared so that its transparency is graded to reduce the intensity at those parts of the plate where the most active wave-lengths are being impressed. Such a screen may be produced by exposing a plate, of the same make as the one to be corrected, to the spectrum of the light which is to be used for the source in the absorption spectra work. The negative thus produced is placed in juxtaposition with the subsequent plates used, and can be adjusted so as to give uniform action.

C. P. B.

211. *Density in Dry Plates and Photographic Photometry.* A. Callier. (Photographic Journ. 58. pp. 242-257, Nov., 1918. 16th Traill Taylor Memorial Lecture.)—A study of the want of uniformity of the resultant density in plates exposed to uniformly lighted surface; unreliability of stand

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development ; causes of want of homogeneity in the plates. A simple method for spectrophotometry in the ultra-violet as well as with visible rays. A new NiCl_2 absorption standard.

A. D.

212. *Physical Chemistry of Photographic Development.* C. E. K. Mees. (Amer. Chem. Soc., Journ. 85. pp. 1727-1732, Nov., 1918.)—The author discusses, from the physico-chemical point of view, the constitution of the photographic emulsion, the effect of light upon that emulsion, the chemical nature of the reducing agent or developer employed, and equilibrium in development.

T. H. P.

213. *Electrochemistry of Light.* X. W. D. Bancroft. (Journ. Phys. Chem. 17. pp. 596-602, Oct., 1918. From a paper read before the 8th Internat. Congress of Applied Chemistry, New York, 1912.)—Further consideration of this subject [see Abstract No. 810 (1918)] leads the author to the following conclusions :—Although it is correct to say that only those rays that are absorbed produce chemical action, it is incorrect to add that some absorbed rays have no tendency to produce chemical action. The statement that light acts like a voltaic cell is not adequate to account for all the facts, although it has proved an admirable working hypothesis up to a certain point. The most satisfactory formulation of the chemical action of light is that all radiations which are absorbed by a substance tend to eliminate that substance ; whether any reaction occurs and, if so, what are the products, are matters for chemical investigation. One and the same substance may react in different ways when subjected to the influence of different radiations. No theory has yet been advanced which allows of the prediction of the relative efficiencies of lights of different wave-lengths.

T. H. P.

214. *Light-energy for Photographic Latent Image.* P. G. Nutting. (Nature, 92. p. 298, Nov. 6, 1918.)—Consider an exposure sufficient to produce a deposit of unit density, that is, one which will transmit but one-tenth of the incident light. A negative has unit density when the silver deposit is 10 mgm. per dm^2 , or 0.1 mgm. per cm^2 . This amount of silver represents roughly 10^{12} molecules, or 10^7 grains 8μ in diam. Now the amount of light-energy required to produce an exposure giving unit density is of the order of 10^{-7} watt-sec. (erg) per cm^2 ; and therefore 10^{-14} erg per grain. The simplest assumption to be made is that one electron per grain is detached from one molecule ; such a liberation would require 5×10^{-12} erg, or less—a quantity consistent with that calculated above from the known exposure and mass of silver.

E. H. B.

215. *Optic Properties of a Liquid Mixture.* A. Cotton, H. Mouton, and P. Drapier. (Comptes Rendus, 157. pp. 1063-1065, Dec. 1, 1918.)—An account of experiments relating to theory of molecular symmetry previously given by Cotton [see Abstract No. 899 (1918)]. The experiments have been carried out with mixtures of finely powdered crystallised calcium benzoate in aniline. The results show that the method of studying the symmetry of the molecules indicated by Cotton is applicable to liquid mixtures containing ultramicroscopic particles. To complete the study a much larger electromagnet would be required than the one used, which gave a field of 4000 gauss.

A. W.

216. *Reality of the Ether.* G. Sagnac. (Comptes Rendus, 157. pp. 1410-1413, Dec. 22, 1918.)—In a previous paper [see Abstract No. 65 (1914)] the

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author has shown that an interferograph whose circuit surrounds a certain area, and which turns in the plane of the circuit, registers its motion with respect to the æther of space. Experiments are here described which show that in the surrounding space the light is propagated with a velocity independent of the motion of the luminous source and of the optic system. This property of space characterises experimentally the luminous æther, and the experiments thus tend to prove the reality of the æther. A. W.

217. Optical Resonance. Damping of Luminous Vibrators. L. Dunoyer. (Comptes Rendus, 157. pp. 1068-1070, Dec. 1, 1918. Le Radium, 10. pp. 400-402, Dec., 1918.)—In a previous paper [see Abstract No. 780 (1911)] the author has shown that it is possible to cause to pass out into an evacuated chamber a flux of molecules all having practically parallel velocities due to the thermal agitation of an ordinary gas. This flux is not visible of itself, but by means of the phenomenon of very pure optical resonance exhibited by the gaseous molecules of sodium when they are excited by the light of the Na D-lines, it has been found possible to render visible, all along its path, the beam of molecular rays. A narrow tube projects radially into a small bulb which can be highly exhausted. On heating the lower end of the tube, which contains a little pure Na, to about 400° C., the rectilinear flux of particles is obtained from the upper end of the tube. The rays are rendered visible by light from a flame fed with a small amount of sodium. The flame is surrounded by a metallic chimney having an opening in the side, an image of which is projected so as to coincide with the path of the rays from the end of the tube. For this purpose a lens system is employed free from spherical aberration. The path of the rays is then easily observed, its boundaries sharply cut off from the general obscurity of the rest of the space in the bulb. The luminosity of the beam persists without appreciable modification for a certain time (about an hour), at the end of which the vapour commences to fill the bulb, as is evidenced by the general luminescence, more feeble than that of the principal beam. If the illumination is confined to a narrow horizontal layer by reducing the opening in the flame chimney to a width of but a few mm., the beam is luminous only in this narrow portion, and the upper and lower boundaries of the luminous portion are at first as sharply defined as the sides. This shows that the molecular resonators only travel an extremely short path, after leaving the space where they are subject to the exciting light, before they cease to vibrate. This result is quite in agreement with the value indicated by Drude as probable for the coefficient of damping of the centres of emission. A. W.

218. Velocity of Light and Carnot's Principle. E. Guillaume. (Archives des Sciences, 86. pp. 401-404, Nov., 1918. Comptes Rendus, 157. pp. 1188-1140, Dec. 8, 1918.)—Discusses the emission theory of W. Ritz [see Abstract No. 886 (1908)] by taking the special case of a luminous disc which is in vibration along its axis, and attributing an inertia to the luminous corpuscles. It is admitted that the velocity of light (c) may be a function of the velocity of the source (v) at the time of emission, viz. $c = f(v) = c_0 + \alpha v + \beta v^2 + \dots$.

E. H. B.

219. Shadows. H. Paschen. (Zeitschr. wiss. Phot. 12. pp. 409-456, Oct., 1918.)—A theoretical and experimental investigation of certain cases where umbra or penumbra are near to or overlapping one another.

A. W.

220. Ether Radiation. A. v. Schütz. (Ann. d. Natur und Kultur-philosoph. 12. pp. 187-205, 1918.)—An endeavour to depict without mathematical analysis a theory of ether radiation applying to electrons, magnets, induction, and light. E. H. B.

221. The Photochemical Equivalent. E. C. C. Baly. (Phys. Zeitschr. 14. pp. 898-899, Sept. 15, 1918.)—When a compound constantly absorbs light of definite colour, the energy so absorbed goes to "open" the electromagnetic fields of the atoms. But this process must be attended by damping, as otherwise the substance would after some time become diactinic. The fields are probably also opened by energy absorbed from the solvent. This is notably the case for the complex aromatic nitro-compounds such as trinitrobenzol, trinitroanisol, and picric acid when dissolved in basic solvents. There are always three stages, consuming equal energies, although the solvents used may be different. This is in accordance with the quanta theory. The action of the solvent accounts for the small value of the photochemical equivalent found by Henri and Wurmser. The Planck-Einstein energy quantum can only be found when the solvent is infinitesimal, as in the transformation of oxygen into ozone. E. E. F.

222. Resonance Radiation of Mercury-vapour. A. v. Malinowski. (Phys. Zeitschr. 14. pp. 884-887, Sept. 15, 1918.)—Studies the effect of a magnetic field on the emission and absorption of the resonance radiation of mercury-vapour discovered by Wood [Abstract No. 1182 (1912)]. The author used a "resonance lamp," consisting of two plates of crystalline quartz placed normally to each other against a brass box containing a drop of mercury. A somewhat similar arrangement, or a brass tube closed at both ends with fluorspar plates, was used as an absorption vessel. Both the resonance lamp and the absorption vessel could be placed in fields up to 6000 gauss. As the field increases both the emission and absorption undergo periodical fluctuations, which were revealed by a photoelectric cell. The author concludes that the resonance line 2586.7 \AA. is not simple, but consists of several lines ranging over an interval of 0.04 \AA. but not resolvable spectroscopically. E. E. F.

223. Polarisation of the Light of Resonance Spectra. R. W. Wood. (Phil. Mag. 26. pp. 846-848, Nov., 1918. Phys. Zeitschr. 14. pp. 1200-1201, Dec. 1, 1918.)—One of the most remarkable and important phenomena observed in connection with resonance spectra is the strong polarisation of the light even when the exciting light is unpolarised. This fact has previously been noticed [see Abstract No. 42 (1912)]. The observations have now been repeated with improved apparatus, and photographs are reproduced showing the fringes obtained by making use of a Fresnel quartz double prism of right- and left-handed rotatory power (such as is used in the study of the magnetic rotation of absorbing vapours). This was found to give fringes somewhat more distinct than the Savart plate previously used. The method of obtaining the fringes is explained. It was found that the percentage of polarisation had practically the same value in all of the lines, including the exciting or resonance radiation line. The percentage of polarisation is not nearly as high as is the case with the vapours of sodium and potassium, for which the author has observed 80 % of polarisation with the exciting light polarised. The fact that the polarisation is the same for all of the lines of the resonance spectrum seems to prove that the numerous vibrations giving rise to lines of
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the resonance spectrum are set up within the atom or molecule by the vibration of the electron which responds to the monochromatic exciting light; in other words, it does not result from anything like dissociation and recombination.

A. W.

224. Resonance Spectra of Iodine under High Dispersion. R. W. Wood. (Phil. Mag. 26. pp. 828-846, Nov., 1918. Phys. Zeitschr. 14. pp. 1189-1200, Dec. 1, 1918.)—A continuation of previous work [see Abstract No. 801 (1918)]. In the present work the exciting light was varied by altering the temperature of the lamp and the voltage drop across its terminals. Improvements in the method of utilising the exciting light made it possible to photograph the resonance spectra in the fourth-order spectrum with a large plane grating and a lens of 2 m. focal length, so that good photographs can be obtained much more quickly than before. Many photographs are reproduced, and the experiments throw much new light on the genesis of resonance spectra. A brief abstract cannot be given.

A. W.

225. Spectra of Helium and Hydrogen. E. J. Evans. (Nature, 92. p. 5, Sept. 4, 1918.)—With reference to the new series of lines observed by Fowler and theoretically investigated by Bohr, the analysis suggests that the two principal series and the Sharp series are given by helium, and it should be possible to obtain the diffuse series from He containing no hydrogen when the Sharp series appears. Experiments by the author on a helium tube showing no trace of hydrogen gave the $\lambda 4686$ line strong in the capillary and faint in the bulb, the pressure being from 0.85 to 1.00 mm. **A. Fowler.** (Nature, 92. pp. 95-96, Sept. 25, 1918.)—Fowler points out that while the 4686 line may be due to He, as suggested by Evans, it must not be hastily concluded that it is not due to hydrogen. Perhaps it may be a case of mutual action of one gas on another, as, for example, the Ritz series of infra-red hydrogen lines was found by Paschen to be brighter in a mixture of H and He than in H alone. Apart from this, the author finds it difficult to believe that the close agreement of one set of lines with the principal series calculated for hydrogen by Rydberg is merely accidental. He regards Bohr's theory as giving no better agreement than that of Rydberg.

C. P. B.

226. Spectra of Helium and Hydrogen. N. Bohr. (Nature, 92. pp. 281-288, Oct. 28, 1918.)—From a theory of spectra based on Rutherford's theory of the structure of atoms, and Planck's theory of black radiation, the author has been led to the conclusion that the new lines observed by Fowler are not due to hydrogen, but that all the lines are due to He and form a secondary helium spectrum exactly analogous to the hydrogen spectrum [see preceding Abstracts]. The author justifies his method of uniting the two series in a single formula by showing the values given for the theoretical and observed lengths of the lines considered. **A. Fowler** replies admitting that in the exact form of the equation given by Bohr there is close agreement between the theoretical and observed values. The corrected Bohr formula leads to the further important result that alternate members of the ζ Puppis series cannot be superposed on the Balmer Hydrogen series as at first appeared. Bohr's theory has not yet been shown capable of explaining the ordinary series of He lines.

C. P. B.

227. Variability of Absorption Spectra. G. H. Livens. (Phys. Zeitschr. 14. pp. 841-844, Sept. 1, and pp. 1050-1052, Nov. 1, 1918.)—Investigates VOL. XVII.—A.—1914.

theoretically the factors which determine the absorption spectrum of a solution [see Abstracts Nos. 168, 1276 (1918)] on the basis of Lorentz's electronic theory, and obtains a more general expression than either Planck or Havelock. In the second article the author discusses the relation of his theory to experimental data, without, however, attempting a definite proof. Shows that in general the situation of the absorption maximum is gradually displaced towards greater wave-lengths when the density of absorbing molecules becomes greater. The amount of displacement is primarily a function of the electrons concerned in the absorption, but also depends upon the active electrons. Beer's law is an approximation for smaller densities. It is not correct to assume that no atom can influence the oscillations proceeding in another atom without actually combining with it. E. E. F.

228. Electric Conditions for the Change from the Arc- to the Spark-spectrum. P. Ludewig. (Ann. d. Physik, 42. 8. pp. 648-664, Oct. 16, 1918. Extract from Freiberg Habilitationsschrift.)—La Rosa has shown [see Abstract No. 1216 (1909)] that in the light from the singing arc there is a change from the arc- to the spark-spectrum according to the relative magnitudes of the self-induction and capacity in the oscillating circuit. Wagner has further investigated the subject. The research here described shows that the spark-spectrum is not necessarily associated with the existence either of a high potential or of electric oscillations. The spark-spectrum arises when the current curve consists of sudden jumps, with sufficiently long pauses lying between. The duration of the impulsive currents must be smaller than 10^{-4} sec. Between the spark-spectrum and the arc-spectrum there exists a continuous series of intermediate spectra, and by increasing the duration of the above-mentioned current impulses the spectrum approaches nearer and nearer to the arc-spectrum. It thus appears that the arc- and spark-spectra take a special place in this series of spectra only because they happen to be, in our present knowledge, the end members of the series. It is quite possible that under suitable experimental conditions the series of spectra may be extended. A. W.

229. Sodium Absorption Lines. C. Füchtbauer and C. Schell. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 974-981, Oct. 30, 1918. Paper read before the 85. Deutsch. Naturforscherversamml., Sept., 1918. Phys. Zeitschr. 14. pp. 1164-1168, Nov. 15, 1918.)—The temperature and pressure were kept constant, and the absorption lines widened by the addition of nitrogen. The following results were obtained :—The sodium D lines both give the same value of the damping parameter. In this case the ratio of numbers of electrons per cm^3 is the same as the ratio of the absorption coefficients, which the author finds to be 2 : 1. This result agrees with Gouy's calculated from emission of flames and Roschdestwensky's from dispersion. The ratio of the number of optical perturbations to the number of collisions is 18 : 1, i.e. about $\frac{1}{18}$ as great as that calculated by Lorentz from Hallo's experiments. The number of vibrating electrons is of the same order as the number of metallic atoms. J. M.

230. Cesium Absorption Lines. C. Füchtbauer and W. Hofmann. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 982-991, Oct. 30, 1918. Paper read before the 85. Deutsch. Naturforscherversamml., Sept., 1918. Phys. Zeitschr. 14. pp. 1168-1172, Nov. 15, 1918.)—A continuation of Füchtbauer and Schell's research [see preceding Abstract], the following being the conclusions arrived
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at :—(a) By using nitrogen filling for tubes the exact condition for absorption may be reproduced. (b) The "half-value-interval" is proportional to pressure as Lorentz's theory demands. (c) Maximum absorption is inversely proportional to pressure. Therefore the number of vibrating particles is independent of pressure of neutral gas filling. (d) Ratio of two lines of doublet decreases with the order. Values are whole numbers and identical for different alkali metals in the same order. (e) Half-value intervals for doublet lines are nearly equal. (f) The number of perturbations calculated from half-value interval is from 20 to 82 times the number of collisions calculated from the gas theory. Both numbers are of same order in the case of series lines and of bands. (g) The number of electrons and of metallic atoms are of the same order for lines of first pair of series. Therefore carriers of primary series lines of alkali metals appear to be the neutral molecules. (h) The intensity is unsymmetrical, the absorption falling off more quickly on the violet than on the red side. J. M.

231. *Distribution of Energy in the Spectra of Gases.* H. L. P. Jolly. (Phil. Mag. 26. pp. 801-827, Nov., 1918.)—The object of the investigations described was, in the first instance, to determine quantitatively the manner in which the energy distribution among the lines of a bright-line spectrum varied when the intensity of excitation was changed. The results of the investigations may be summarised as follows :—(i) If the current in a discharge tube be small, the radiation from it is proportional to the current-density, both for the whole spectrum and for any portion of it. (ii) In heavy discharges such as that produced by a large condenser in parallel with the discharge tube, there is strong evidence that the energy shifts towards the longer wave-lengths when the current-density increases. Whether the energy of any portion of the spectrum increases at a rate greater or smaller than the current has not been determined, owing to the difficulties in the way of measuring these currents. (iii) When the pressure at which a condensed discharge is sent through the tube is increased, the energy shifts towards the longer wave-lengths. A continuous spectrum makes its appearance in these discharges, and becomes more marked the higher the pressure. A. W.

232. *Dispersion of Light in Gases in Ultra-violet Region.* J. Koch. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 20. pp. 1-25, 1918.)—The investigation deals with the dispersion in the ultra-violet region of hydrogen and air. A Jamin interferential refractometer was used, the interference fringes being directed to the slit of a quartz spectrograph by means of a mirror. A high-pressure quartz mercury lamp was used as the source of light. The spectrum was photographed for different pressures in one of two glass tubes containing the gas between the quartz parallelopipeds of the refractometer, the spectral lines appearing crossed by oblique interference bands. The results are discussed with reference to the dispersion theory developed by Lorentz, Planck, Drude, etc. [See Abstract No. 8241 (1904).] A. W.

233. *Dispersion of Light in Gases in Ultra-violet Region.* J. Koch. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 6. pp. 1-11, 1918.)—In a previous paper the author has considered the dispersion of light in hydrogen and air in the ultra-violet region [see preceding Abstract]. The present paper deals with nitrogen and helium. A. W.

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234. Spectrum of Active Nitrogen. E. P. Lewis. (Phil. Mag. 25. pp. 826-882, June, 1918.)—The only invariably characteristic part of the afterglow spectrum are the bands with heads at 6822, 5854, 5442, and 5058, belonging to the "first positive" group. In the author's experiments the afterglow continuously increased in intensity as the proportion of oxygen was reduced, but he doubts whether in any case the nitrogen was completely freed from oxygen or nitric oxide, and the origin of the afterglow still seems an open question. With a sufficiently strong discharge it might possibly be produced with large quantities of oxygen present. No trace of Strutt and Fowler's "fourth group of positive bands" was found on photographs of the spectrum of N freed as far as possible from oxygen, though they appear when there is a slight admixture of oxygen. The author believes that the second group of bands are due to the dissociation produced by the discharge, and the third and β groups are associated with the afterglow and the period of recombination.

E. E. F.

235. Metallic Spectra with the Tube-arc. A. S. King. (Mount Wilson Solar Observatory Contributions, No. 78. Nature, 92. p. 802, Nov. 6, 1918. Abstract.)—In the course of an investigation of electric-furnace spectra by means of a resistance tube, certain interesting variations in intensity of different types of lines were examined, tables of results and typical reproductions of some of the spectra being given in the paper.

C. P. B.

236. Mercury Spectrum in Schumann Region. T. Lyman. (Astrophys. Journ. 88. pp. 282-291, Oct., 1918.)—The mercury spectrum now being used for so many investigations rendered it advisable to obtain a more complete record of its constitution, which previous to the present work did not extend beyond about $\lambda 1850$ [Abstracts Nos. 854, 1581 (1912)]. Lines predicted by Paschen at $\lambda 1849.6$ and $\lambda 1402.5$ have been detected in the mercury arc spectrum; Paschen's third line at $\lambda 1268.9$ is within the limits of the photographs, but has not yet been found. A table is given showing the wave-lengths and relative intensities of 86 lines extending from $\lambda 1269.7$ to $\lambda 1875.7$, and sketches are given of the types of mercury lamps employed.

C. P. B.

237. Band Spectra and their Modifications. H. Deslandres and L. d'Azambuja. (Comptes Rendus, 157. pp. 671-678, Oct. 27, 1918.)—A résumé is given of the progress of knowledge concerning the structure of band spectra rendered possible by the gradual improvement and increase in power of the spectrographs employed for observation from 1885 to 1911. Illustrations are given showing some of the chief advances as found in the bands of the spectrum of nitrogen. (Erratum, Ibid. p. 118, Nov. 8, 1918).

C. P. B.

238. Effect of Electric Field on Spectrum Lines. J. Stark. (Preuss. Akad. Wiss. Berlin, Ber. 40. pp. 982-946, 1918.)—A cylindrical tube was furnished with a flat cathode K perpendicular to the axis of the tube; the cathode was supported at three points and had a number of perforations 1 mm. wide. Just below this was fixed an auxiliary electrode H; this was unperforated, and in some experiments was 2.6 mm., in others 1.1 mm. from the cathode. The anode A was sealed into the other end of the tube. A and K were connected to a large induction coil. H and K were connected to a steady current source, H to the negative, K to the positive pole. The gas pressure was reduced till the length of the dark space was 5 to 10 cm. For the constant

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p.d. between H and K a dynamo (4500 volts) was used, with a battery of accumulators (8800 volts). Sometimes the two were connected in series, at other times the battery alone was used. With this arrangement the effect of the electric field on various spectrum lines was investigated. Photographs were taken, the exposures varying from 25 mins. to 8 hours. Observations of the transversal effect with the hydrogen lines H_β , H_γ show that they are each split up into five components by the action of the electric field, the oscillations of the three middle components being parallel, and the two outer ones perpendicular, to the direction of the electric field. The centre component lies very near to the position of the original line, apparently being slightly displaced towards the side of longer wave-lengths. The potential gradient in these experiments was 18,000 volts/cm. In helium the lines $\lambda 4472$ and $\lambda 4026$ of the first subordinate series are split up into three components with oscillations parallel, and three with oscillations perpendicular to the direction of the field. Diagrams are given for these and for other lines dealt with. Investigations of the dependence of the effect on the field strength show that to a first approximation the dispersion is proportional to the first power of the field strength. The experiments show that it is probable that the members of the same series of spectrum lines are affected in the same manner by the electric field, as regards the number, oscillation directions and intensity ratios of their components. The splitting-up of a line into components appears to be the only thing common to the new effect and the Zeeman-effect; in other respects they differ. The electric dispersions for different series lines differ from one another in order of magnitude; the magnetic dispersion is for all series lines of the same order of magnitude. The distance apart of the Zeeman components of a line in a given series is proportional to the square of its wave-length; the distance of its components in an electric field, at all events for numerous lines, increases with decreasing wave-length. Homologous series lines of different elements show in numerous cases the same Zeeman-effect, with certain reservations; in the new effect the lines of H and He exhibit quite different behaviour. Further investigation of the phenomenon should lead to a better understanding of the dynamics of the atom. A. W.

239. *Ultra-violet Lines.* R. Wolff. (Ann. d. Physik, 42. 4. pp. 825-889, Nov. 4, 1918.)—The author has examined the arc spectra of zinc, cadmium, and mercury to the transparency limit of fluor spar, discovering the primary series and the combination series calculated by Paschen [see Abstracts. Nos. 1486 (1911), 985 (1918)]. Taking these series lines as standards he has fixed the position of several uncertain mercury and hydrogen lines and measured new carbon and silicon lines. J. M.

240. *Zeeman-effect.* R. Fortrat. (Comptes Rendus, 157. pp. 686-689, Oct. 20, 1918.)—A further examination of the sodium doublet $\lambda = 2858$. [Abstract No. 1440 (1918)] in a field of 49,400 gauss, obtained with a Weiss ferro-cobalt electromagnet [Abstract No. 1511 (1918)]. The author finds his results in close agreement with those calculated from Voigt's theory if all the lines are displaced 0.08 \AA . [See Abstract No. 1826 (1918).] J. M.

241. *Production of Luminescence by Kathode and Canal Rays at Liquid-air Temperature.* E. Ohlson. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 22. pp. 1-20, 1918.)—A large number of minerals and metallic salts are examined with regard to their properties of emitting luminescence under the action of both kathode and canal rays. The observations with the VOL. XVII.—A.—1914.

minerals were of a preliminary character only and revealed the fact that the intensity of the luminescence produced by these agencies was much greater at low than at ordinary temperatures. Consequently the observations with the metallic salts were made at the temperature of liquid air. With the salts of the more electropositive metals, viz. Li, Na, K, Ca, Ba, Sr, and Mg, two types of luminescence are to be observed. When the salts are first subjected to the rays a bluish luminosity is seen which, however, diminishes in intensity, in some cases rapidly, giving place to a second luminescence which varies in colour according to the salt. With the salts of Zn, Cd, Pb, Hg, Fe, Cu, and Mn, luminescence of the second type only is to be observed. The author concludes, after comparing his results with those of Goldstein [see Abstract No. 717 (1912)] and others, that the first type of luminescence, which is similar for different materials, is caused by the escape of electrons, since it occurs with salts of the photoelectric metals; the second type is due to the escape of the metal atoms which have previously lost their valency electrons, for in some instances when canal rays are the exciting agency the luminosity gives line spectra characteristic of the metal. The spectra, however, generally consist of bands. The experimental results are given in tabular form and include observations on the phosphorescence and thermoluminescence of the substances.

F. J. H.

242. Fluorescence of Sulphur, Selenium, and Tellurium Vapour. W. Steubing. (Phys. Zeitschr. 14. pp. 887-893, Sept. 15, 1913.)—The sixth vertical column of the periodic system shows 4 elements whose vapours are capable of fluorescence: O, S, Se, and Te. The exciting radiation for these is below 2000 Å. in the case of oxygen, between 2500 and 8200 in the case of sulphur, above 8000 in the case of Se, and in the case of Te it lies in the most refrangible portion of the visible spectrum. The fluorescence requires vapour of definite density and temperature. Thus sulphur must be superheated to 400° to 500° C. The fluorescence spectra are discontinuous and show ill-defined groups of lines resembling bands. They are greatly weakened by the admixture of foreign gases and vapours.

E. E. F.

243. Photography of Röntgen-ray Spectra. M. de Broglie. (Comptes Rendus, 157. pp. 924-926, Nov. 17, 1913. Deutsch. Phys. Gesell., Verh. 15. 24. pp. 1348-1349, Dec. 30, 1913.)—From the researches of Laue and Bragg we know that the Röntgen rays reflected from a face of a crystal ought, according to the generally accepted theory, to have a wave-length λ such that $n\lambda = 2d \sin \theta$, where n is a whole number, d the distance of the reticular planes parallel to the plane of reflection, and θ is the complement of the angle of incidence on this plane. A crystal was mounted on the cylinder of a registering apparatus arranged to turn with an angular velocity of about 2° per hour. At the start the incident beam X is parallel to the face considered of the crystal; the angle of incidence varies regularly with the time, and the reflected beam, which turns twice as fast, sweeps across a photographic plate and gives a continuous record. If there exist in the incident beam more intense wave-lengths, corresponding to definite values of θ , the reflected ray, inclined at 2θ to the incident beam, will mark more intense lines on the plate. Thus a line spectrum is obtained, having the appearance of an ordinary luminous spectrum, with lines fine or diffuse, bands, etc. If the incident beam could be kept constant for the whole time of the experiment nothing further would be required, but this can only be realised in general in a rough manner when the exposure is not long. Hence it is

necessary to add a second registering apparatus, giving at each instant the intensity of the incident beam. A much less sensitive emulsion is required for the photographic plate for the latter purpose. Using a crystal of rock-salt a remarkable series of fine lines and bands was obtained on a continuous ground. The complete study of these plates is not yet finished, but it appears certain that the principal lines do not correspond to the maxima noted by Bragg, Moseley, and Darwin in their ionisation measurements. This is not surprising, since the ionisation method is usually carried out with very soft tubes, while the present results were obtained with hard tubes.

A. W.

244. Spectrum of Röntgen Rays. M. de Broglie. (Comptes Rendus, 157. pp. 1418-1416, Dec. 22, 1918.)—In a previous paper [see preceding Abstract] a method was described of obtaining the spectrum of Röntgen rays by slowly rotating a crystal, so that the angle of incidence varied continuously. The method has now been further investigated and the results show that the spectrum is characteristic of the substance used as the antikathode. Various tubes, with antikathodes of platinum or tungsten, have each regularly furnished their characteristic spectra using various crystals of fluorine, pyrites, sylvine, calcspar, and rock-salt. The latter is particularly suitable on account of the intense images which it gives. The following table is an example of the spectrum obtained, using a tungsten antikathode and an analyser of rock-salt:—

Intense band, sharp towards long wave-lengths ...	0° to about 8° 50'
Less intense band	8° 50' to about 9°
Fine line, mean intensity	10° 25'
Doublet { I intense	11° 55'
{ II mean intensity.....	12° 20'
Line, mean intensity	14° 30'

Debye has recently given a remarkable formula for the intensity of a diffraction maximum of a Röntgen beam of wave-length λ by a crystal at absolute temperature T . This intensity is proportional to $e^{-2\epsilon}(1 - \cos \delta)$, δ being the angle between the incident and diffracted rays and ϵ being given by $\epsilon = 4\pi^2 KT/f\lambda^2$. K is a universal constant and f an elastic constant of the crystal, related to what has been called the proper period of the body. But λ and $(1 - \cos \delta)$ are not independent, for $n\lambda = 2d \sin(\delta/2)$, where d is the distance between the parallel planes of the plane reflector which furnishes the diffraction maximum and n is the order of the spectrum. If $n=1$, $\lambda = 2d \sin(\delta/2)$, and $2 \sin^2(\delta/2) = 1 - \cos \delta = \lambda^2/4d^2$. Substituting in the expression for the intensity, it is seen that this now contains neither δ nor λ ; it only depends on T for a given crystal. Hence, with the restriction as to the order of the spectrum, the effect of temperature on the intensity of a diffraction maximum does not depend on the angle δ , or rather it only depends on it very indirectly through the quantity d . Experiments have already furnished the expected verification of a first consequence of the theory of Debye, *i.e.* the fact, sufficiently surprising at first sight, of the sharpness of diffraction maxima, which appear as independent of the temperature. The variation with temperature of the relative intensity of these maxima has been found apparently to be smaller than is indicated by Debye's formula in its original form, but the above gives some explanation of the observed differences.

A. W.

245. Energy of Röntgen Rays. R. T. Beatty. (Roy. Soc., Proc. Ser. A. 89. pp. 814-827, Nov. 1, 1918.)—The experiments deal with a determination of the amount of energy which reappears as Röntgen radiation when kathode rays of given speed fall on antikathodes of different metals. A pencil of homogeneous kathode rays is sorted out by means of a magnetic field and allowed to fall on an antikathode. The resulting X-rays escape through a diaphragm with practically no absorption, and are then completely absorbed in a long ionisation chamber containing air saturated with methyl iodide. To avoid variations of the intensity of the source the ratio of the total ionisation current to the current carried by the kathode particles themselves is measured by a special null method. In this way it is found that the total ionisation produced by the X-rays in the chamber is proportional to the fourth power of the velocity of the kathode rays producing them, i.e. $X = 0.58 A \beta^4$, where X is the total ionisation current (4π) due to the X-rays per unit of kathode-ray current, A the atomic weight of the radiator and β is the ratio of the velocity of the kathode rays to the velocity of light. This relation only holds in cases where the characteristic radiation is not being excited. The next step is to find how much energy the X-rays possess relatively to the energy of the primary kathode rays. This is taken as equal to X/N , where N is the number of pairs of ions which would be produced by the primary kathode rays. N is assumed to be the same as in air and is calculated from Glasson's results for the number of ions per cm. of path produced by kathode rays, and Whiddington's results on the rate of loss of energy of kathode particles. In this way X/N is found to be equal to $2.54 \times 10^{-4} A \beta^2$. For example, if a Pt radiator be excited by kathode rays of speed 10^{10} cm./sec., $A = 195$, $\beta = \frac{1}{2}$ and $X/N = 5.51 \times 10^{-2}$. This is the energy of the "independent X-rays"; the characteristic rays which will be excited in this example will increase the total energy emitted. E. M.

246. Experiments on the Reflection of X-rays. R. W. A. Salmond. (Röntgen Soc., Journ. 9. pp. 98-102; Discussion, pp. 102-105, Oct., 1918.)—The paper gives details of interesting photographs obtained by allowing a beam of X-rays to fall on mica and a few other crystals. E. M.

247. Quantitative Determination of Radium Emanation. L. Flamm and H. Mache. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 585-542, March, 1918. Phys. Zeitschr. 14. pp. 1122-1125, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien, Sept., 1918.)—Using guard-ring plate electrodes the authors find that the ionisation current for pure emanation is 2.75×10^8 e.s. units per curie. To obtain this value [see Abstract No. 75 (1918)] corrections have to be applied for initial recombination in the α -ray ionisation columns. The above number agrees almost exactly with that calculated from the number of α -particles emitted per sec. and the number of ions produced by each α -particle. E. M.

248. Determination of Radium in Radio-active Substances. A. L. Fletcher. (Phil. Mag. 26. pp. 674-677, Oct., 1918.)—A small splintered and weighed fragment of the mineral or salt under investigation is placed in a hollow in a carbon rod. A current is sent through the carbon so as to raise the temperature to about 2500° C. In about 20 seconds this completely de-emanates the specimen and the emanation can be pumped off into an electroscope. Results are given which show that the method is very reliable. In one of the experiments it is shown that a temperature of 900° C. is necessary to completely de-emanate pitchblende in 1 minute. E. M.

249. Distribution of the Active Deposit of Radium in an Electric Field. E. M. Wellisch. (Amer. Journ. Sci. 36. pp. 815-827, Oct., 1918. Phil. Mag. 26. pp. 628-635, Oct., 1918.)—A continuation of the experiments described in Abstract No. 1089 (1912). It is shown that when the emanation is mixed with any gas there appears to be a definite limit to the fraction of the active deposit which settles on the kathode. The limit is independent of the pressure of gas, provided it is high enough to prevent the deposit particles from recoiling on to the walls of the vessel; it is in general dependent on the nature of the gas. It is shown that even in air which has been thoroughly dried, the recombination between the positively-charged deposit particles and negative ions is greater than the recombination between ordinary positive and negative ions. Thus as it moves through the gas the recoil atom of the active deposit (RaA) produces a large number of ions, and in the act of ionisation it is possible that the recoil atom may lose its positive charge. The process is in many respects similar to that which is known to occur in the case of canal rays. In ether, the molecules of which are easily ionised, this special recombination effect is very prominent as only 90 % of the total activity can be concentrated on the kathode. E. M.

250. Alpha-rays from Thick Layers. L. Flamm. (Phys. Zeitschr. 14. pp. 812-815, Sept. 1, 1918.)—A method of exact integration is given for E. v. Schweidler's expression [Abstract No. 1672 (1918)] for the ionisation above thick layers of a substance emitting α -rays, and it is shown how it can be utilised by means of simple auxiliary experiments, based on the apparatus used by Bragg for studying the ionisation of argon and helium. E. E. F.

251. Analysis of the β -Rays from Radium B and Radium C. E. Rutherford and H. Robinson. (Phil. Mag. 26. pp. 717-729, Oct., 1918.)—The authors have made detailed measurements of the velocities of the homogeneous groups of β -rays emitted from RaB and RaC, the values being calculated from measurements of the deflection in known magnetic fields. The results are represented in a diagram in the original, which is, however, too large for reproduction here. In this, values of $H\rho$ and of energy ($10^{12}e$) for RaB and RaC are shown juxtaposed (where $H\rho = mv/c$; m , v , and c being the mass, velocity, and charge of the β -particles and ρ the radius of curvature in a magnetic field of strength H). The energy E is calculated from the Lorentz-Einstein formulæ—

$$E = m_0/c \cdot c^2 [1/\sqrt{(1 - \beta^2)} - 1] ; m/m_0 = (1 - \beta^2)^{-\frac{1}{2}} ;$$

where $e/m = 1.772 \times 10^7$, c is the velocity of light, and $\beta = v/c$. It is found that for RaC, which is known to give only one type of γ -rays, the energies of most of the pencils of β -particles differ by an integral factor of a constant $E_1 = 0.4284 \times 10^{12}e$. This presumably represents the energy in a single γ -ray [Abstract No. 435 (1918)]. It is also noticed that the energy of each of the pencils is nearly an integral multiple of the common difference (E_1). E. M.

252. Scattering of α -Particles by Gases. E. Rutherford and J. M. Nuttall. (Phil. Mag. 26. pp. 702-712, Oct., 1918.)—In the experiments a narrow pencil of α -particles was obtained by placing a thin Pt-wire coated with RaC between two thick glass plates about 15 cm. in length and 0.8 mm. apart. After traversing the space between the glass plates, which were in a chamber that could be exhausted, the α -particles passed through a mica window into an ionisation chamber where measurements could be made of their intensity. A gas was introduced into the space between the glass plates, and the number of α -particles taken from the beam by scattering into the plates was estimated.

It was shown that if N_0 is the number of α -particles in the emerging beam at zero pressure and N_p at pressure p , then $N_p = N_0 e^{-\lambda p}$, where λ may be called the "scattering coefficient" for the particular gas under the given conditions. This equation only holds as long as the α -particles are not appreciably altered in velocity by traversing the gas between the plates. It was shown that $\lambda \propto 1/v^4$, where v is the initial velocity of the α -particles, and from this and other considerations it is deduced that the scattering is of the "single" type, *i.e.* due to single encounters with the atoms in the gas [Abstract No. 1847 (1911)]. If the central nucleus of the atom has a charge ne it is deduced that $\lambda = cn(n+1)$, where c is a constant. The gases used in the experiments were air, CH_4 , CO_2 , O_2 , S , H_2 , and He , and assuming the result of Geiger and Marsden [Abstract No. 1296 (1918)] that carbon has a central charge $6e$, it is deduced that the helium atom has a central nucleus with charge $2e$, and that hydrogen has a central nucleus with charge e . This simple structure for H - and He -atoms has been assumed by Bohr in recent papers on the constitution of atoms, and shown to yield very promising results [see Abstracts Nos. 1980 (1918) and 15 (1914)].

E. M.

253. Scattering and Absorption of the γ -Rays of Radium. J. A. Gray. (Phil. Mag. 26. pp. 611-628, Oct., 1918.)—Florance has shown that the secondary or scattered γ -rays become less penetrating as the angle of scattering is increased [Abstract No. 851 (1911)]. This result has generally been explained by assuming that the primary γ -rays are heterogeneous and that the softer rays are scattered through larger angles. In the present experiments the author shows, by first absorbing soft radiations, that this is not necessarily the case, but that when γ -rays are scattered they undergo a change in quality. The change in quality is gradual and small when the angle of scattering is small. It is shown that the quality and quantity of the scattered radiation is approximately independent of the nature of the radiator. The softer the type of γ -rays the greater the percentage scattered per unit mass. A discussion is given of the bearing of the results on absorption experiments, and it is deduced that an exponential law signifies heterogeneity of the rays. In the case of X-rays scattering is in most cases so small compared with absorption that an exponential law probably signifies homogeneity.

E. M.

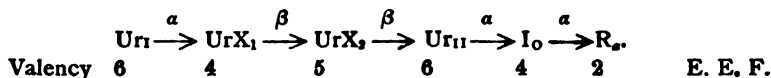
254. Reflection of γ -Rays from Crystals. E. Rutherford and E. N. da C. Andrade. (Nature, 92. p. 267, Oct. 30, 1918.)—Rutherford and Richardson [Abstract No. 1675 (1918)] have shown that RaC emits one, and RaB emits three types of γ -radiation each of which is exponentially absorbed by Al . The present paper deals with an examination of these types of radiation by the methods developed for X-rays by W. H. and W. L. Bragg and by Moseley and Darwin, which consist in determining, either by the photographic or the electric method, the intensity of the X-rays reflected from a crystal at different angles of incidence. In the experiments the source of γ -radiation was a thin-walled " α -ray" tube containing about 100 millicuries of emanation in equilibrium with its products A, B, and C. A diverging cone of rays fell on a crystal of rock-salt, and the distribution of the reflected radiation was examined by a photographic plate placed 10 cm. from the centre of the crystal. A group of fine lines comprised between the glancing angles 8° and 10° was observed on the photographic plate. Similar results were obtained with a crystal of potassium ferrocyanide. It is hoped that in this way definite evidence will be obtained on the constitution and wave-length of each of the types of γ -radiation emitted from RaB and RaC .

E. M.

255. Speed of δ -Rays. N. Campbell. (Phil. Mag. 26, pp. 774-775, Oct., 1918.)—It was recently shown [see Abstract No. 1877 (1918)] that theory predicted that the distribution of velocities among δ -rays from metals should be independent of the nature of the primary rays, but that it gave too small a value for the number of very slow δ -rays (under 20 volts). This discrepancy is now removed by the work of Bumstead [Phil. Mag. 26, p. 288, 1918, also Abstract No. 1877 (1918)]. Indeed there appears to be nothing in our present knowledge of the δ -rays inconsistent with the view that they represent the electrons ejected from atoms by the passage through them of charged particles in accordance with the simple theory of that action given by Thomson.

E. H. B.

256. Uranium X₁. K. Fajans and O. Göhring. (Phys. Zeitschr. 14, pp. 877-884, Sept. 15, 1918.)—Uranium X consists of two successive products: UrX_1 , with a half-period of 24.6 days, and a new short-lived product now called UrX_2 . The latter has a half-period of decay of 1.15 mins., and its radio-active constant of disintegration is 0.0100 sec.^{-1} . UrX_2 emits only hard β -rays, identical with those of UrX (absorption coefficient in Al = 15 cm.^{-1}). The soft rays of UrX are attributable to UrX_1 (500 cm.^{-1}), which does not emit hard rays. These facts bear out the rule that very hard β -rays are only emitted by short-lived substances, and very soft β -rays by long-lived substances. UrX_2 is electrochemically nobler than UrX_1 . Its chemical properties place it in the fifth group of the last horizontal row of the periodic system, and make tantalum its nearest congener. The revised Ur series becomes—



257. γ -Rays from the Products of the Thorium Series. L. Meitner and O. Hahn. (Phys. Zeitschr. 14, pp. 878-877, Sept. 15, 1918.)—In order to furnish further data towards a study of the nature of γ -rays, the authors determine the distribution of γ -ray activity among the members of the Th series. It turns out that ThX possesses a γ -radiation whose absorption is greater than the average absorption of the γ -rays of the active deposit. In ThB a γ -radiation is found which is absorbed to the extent of 50 per cent. by 1 mm. of lead, and constitutes 22 per cent. of the total γ -radiation. If ThC emits a γ -radiation at all, its penetrating power is identical with that of ThD for all thicknesses of lead between 0 and 19 mm. [See also Abstracts Nos. 888 (1911), 1715 (1912).]

E. E. F.

258. Range of Recoil Atoms from Thorium C and Actinium C. A. B. Wood. (Phil. Mag. 26, pp. 586-597, Oct., 1918.)—In the active deposits of actinium and thorium the recoil radiations arise from the emission of the α -particles from the C products. In the present paper the "ranges" of these recoil atoms have been determined by two methods. In the first method a small disc coated with active deposit was placed at the centre of a hemisphere in a vessel which could be exhausted. The amount of the D product received on the hemisphere was investigated for different pressures by subsequent observation of its β -ray activity. The limiting pressure (p) at which no D-atoms reached the hemisphere was observed, and the range R at atmospheric pressure calculated from $R = pd/760$, where d is the distance from the active disc to the surrounding hemisphere. In the second method an arrangement

of a wire gauze similar to Bragg's method of determining the range of α -particles was used, since it is known that a recoil atom is a very efficient ioniser [Wertenstein, Abstracts Nos. 1586 and 1848 (1912)]. In the case of actinium C the two methods gave the same results, 0.125 mm. in air and 0.55 mm. in H. In the case of ThC, however, the first method gave 0.12 mm. in air and 0.55 mm. in H, while the ionisation method gave 0.175 mm. in air and 0.74 mm. in H. The range of the α -particles of AcC is 5.4 cm., while in ThC there are two sets of α -particles emitted on different branches with ranges 4.8 cm. and 8.6 cm. The ionisation method gives the range of the recoil atom corresponding to the swiftest α -particle, and as the range of the recoil ThD is much less than the range by the ionisation method, ThD must arise by disintegration of ThC₁, which gives the α -particle of range only 4.8 cm. This agrees with the scheme of disintegration suggested by Marsden and Darwin [Abstract No. 1714 (1912)]. E. M.

259. Penetrating Radiation. V. F. Hess. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1068-1077, June, 1918. Phys. Zeitschr. 14. pp. 610-617, July 15, 1918.)—The penetrating radiation found throughout the atmosphere is usually attributed to traces of RaC, but measurements with emanation apparatus show only $1.6 \times 1.9 \times 10^{-12}$ curie per cm.³, which is some 20 times too little to account for the penetrating radiation observed. The latter, it is true, is increased in closed rooms by the secondary γ -rays emitted by the walls, but this increase amounts to only some 20 per cent. At heights of 1000 m. and more, at which free balloon observations of the penetrating radiation were made by Gockel and the author, there is an increase in the penetrating radiation, and since at such heights all radiation from the earth's surface is ineffective, and the amount of emanation and RaC is not likely to be greater than at the earth's surface, the author concludes that the penetrating radiation is due to some unknown radio-active substance. E. E. F.

260. Gradient of Penetrating Radiation from the Earth. L. V. King. (Phil. Mag. 26. pp. 604-611, Oct., 1918.)—The author works out the formulæ for the gradient of the ionisation due to the penetrating radiation from radium in soil, etc., both upwards into the atmosphere and downwards below the surface of the soil. Using the most recent data, curves are given to represent actual conditions. Thus at a height of 888 m. the penetrating radiation is reduced to 0.087 of its surface intensity, while at a depth of 16.7 cm. its value is 1.968 of that at the surface. The author next discusses the various experimental observations of ionisation in the atmosphere. In the case of balloons it is probable that during the ascent the potential of a balloon is several thousand volts higher than the air in its immediate neighbourhood, so that it acts as a collector for active deposit present in the atmosphere. A list of precautions is given for experiments on the measurement of the gradient of the penetrating radiation in the atmosphere. E. M.

261. Radio-activity of the Carbonated Springs of Mt. Iduna, Sinano. D. Isitani. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 150-156, Oct., 1918.)—The springs in question are cold and arise from an extinct volcano. The mean amount of radium emanation per litre of water was found to be 80×10^{-12} curie. E. M.

HEAT.

262. Absolute Thermal Conductivity of Glass. I. Williams. (Phil. Mag. 26. pp. 598-604, Oct., 1918.)—A new method of measuring the thermal conductivity of glass by radial flow in a thick-walled capillary tube is described. A horizontal capillary has wide vertical glass tubes sealed to its ends. The whole is filled with mercury and placed in a vessel through which water circulates rapidly. Heat is communicated to the inside of the capillary by sending a current through the mercury, the quantities communicated to lengths l_1 and l_2 in series being obtained from the current and the p.d.'s between leads inserted in holes bored in the tube at the ends of these lengths. The difference in these two amounts is considered to give the quantity of heat conducted through the glass for a length $l_1 - l_2$, end effects being thus eliminated. The radial fall of temperature is measured with a thermo-couple having one junction in the mercury at a point between the two lengths considered and the other in the surrounding water. The author purposes using the method for measuring the temperature coefficient of thermal conductivity of glass and quartz. F. J. H.

263. Volume-changes of Amalgams. J. Würschmidt. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1027-1086, Oct. 80, 1918.)—The author has continued the study of the expansion of amalgams [see Abstract No. 719 (1918)]. In the case of tin amalgams the coefficient of expansion begins to increase below the melting-point and has its max. value at the melting-point. So sharp is this that the property can be employed for determining the melting-point. In the case of zinc amalgams the max. value of the coefficient of expansion is found below the melting-point, but it was found that the coefficients of expansion depend on the past history of the amalgam. The maximum of the coefficient is caused by time changes of the volume. Bismuth amalgam, like pure Bi, shows a contraction at the melting-point, but this contraction begins far below the melting-point and reaches its first maximum at 90°. A. F.

264. Specific Heats of certain Diatomic Gases. W. Escher. (Ann. d. Physik, 42. 4. pp. 761-778, Nov. 4, 1918. From papers published by F. Richarz and the author at the University of Marburg.)—The earlier determinations of the specific heats of gases have been thought by Richarz to be inaccurate since they give wrong values for the mechanical equivalent of heat calculated by Mayer's method from these determinations and the ratio of specific heats. At the suggestion of Richarz, Everts, Stoll and the author have redetermined the specific heats of nitrogen, oxygen, hydrogen, and air by the method of mixtures. In the present paper the determinations of the specific heats of hydrogen and air are fully described, and the results of all three observers compared with those of Scheel and Heuse [see Abstract No. 827 (1918)]. In the experiments observations are made at a mean temperature of about 60° C., and the various corrections peculiar to the method are determined and allowed for. From the general relation $M \cdot C_p = M \cdot C_v + 1986$, where M is the molecular weight, the author calculates the values of C_p/C_v , which agree well with the well-known

directly determined values; those calculated from the determinations of Scheel and Heuse are not in such good agreement. The values of the mechanical equivalent of heat are also calculated from the various determinations by the use of van der Waals' equation, and compared with the accepted value. F. J. H.

265. Anomalous Specific Heats of Certain Alloys. O. Richter. (Ann. d. Physik, 42. 4. pp. 779-795, Nov. 4, 1918.)—The earlier observations of the author's on the specific heats and densities of certain alloys [Abstracts Nos. 1545 (1912) and 445 (1918)] are now examined to test the applicability of Richarz's rule to these alloys. According to this rule those alloys which depart from the law of mixtures for their densities should show a departure in the opposite direction from the same law as applied to their specific heats. This is found to be the case for Bi-Sn alloys. With Bi-Pb alloys, however, in which the departure from the law of mixtures is considerable, the rule does not apply, greater densities being accompanied by greater specific heats. The curve, specific heat plotted against percentage composition, shows a max. specific heat for a 50 % alloy, and consists practically of two straight lines intersecting at this maximum, there being, however, a slight minimum near the 100 % Pb point. This minimum no longer exists if the liquid alloy is not heated to a high temperature before casting, from which, with other considerations, it is concluded that the physical properties of certain alloys depend not only on the relative quantities of the elements used in their formation, but also on the method of casting them and upon their past thermal history. The form of the corrected curve, viz. the two straight lines, is explained by the presence of a chemical compound Bi_2Pb_3 , which alone is present at the maximum, but which on either side of the maximum is mixed with the excess of the corresponding metal. The specific heats and densities can thus be calculated by applying the law of mixtures to mixtures of Bi_2Pb_3 and Bi, and Bi_2Pb_3 and Pb. The author concludes that Richarz's rule applies only to alloys containing neither chemical compounds nor eutectics.

F. J. H.

266. Space Lattices and Specific Heat. H. Thirring. (Phys. Zeitschr. 14. pp. 867-878, Sept. 15, 1918.)—Works out the rigid integral expression of Born and Kármán [Abstract No. 626 (1918)] for the energy-content and specific heat of regular crystals as a function of the temperature and the elastic constants, by means of exponential series. Determines in this manner the specific heat of copper, rock-salt, and sylvine. The results show disagreements from the experimental values ranging from 6 to 16 per cent., but this is probably due to the use of elasticity constants applicable to ordinary as distinguished from very low temperatures. E. E. F.

267. Compressibility and Difference of the Specific Heats with Liquids. T. Peczalski. (Comptes Rendus, 157. pp. 770-778, Nov. 8, 1918.)—In order to obtain a formula representing the isothermal compressibility of liquids, reasoning similar to that applied to the case of gases may be employed. Thus, if $dv/v = -a/\beta \cdot dp/p$ is the differential equation for the transformation of liquids at constant temperature, and $a/\beta = a - bp - cp^2 - \text{etc.}$, substitution and integration give, $\log v = \text{constant} - a \log p + bp + cp^2/2 + \text{etc.}$, and hence $v = A p^{-a} e^{bp + cp^2/2 + \text{etc.}}$, where $A, a, b, c, \text{etc.}$, are functions of the temperature alone and e is the base of the natural system of logarithms. Since at zero pressure v is finite and differs from zero, a must vanish

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in the case of liquids and solids. Thus the two equations become: $v = Ae^{bp + cp^2/2 + \text{etc.}}$, and $\alpha/\beta = -bp - cp^2$, etc., and the coefficient of compressibility, μ , is equal to $\alpha/\beta p$. Taking only two terms in the exponent of e , the expression for v gives results in satisfactory agreement with those obtained by Amagat for water at 0° and for ethyl alcohol at 0° and 40° . By means of the coefficients of expansion, α and β , it is possible to obtain an expression for the difference between the specific heats at constant pressure, C_p , and at constant volume c . Clapeyron's equation gives—

$$C - c = T/J \cdot \partial p / \partial t \cdot \partial v / \partial t,$$

in which T is the thermodynamic temperature and J the mechanical equivalent of heat. Since $\partial p / \partial t = p\beta$ and $\partial v / \partial t = v\alpha$, this gives—

$$C - c = T/J \cdot v p \alpha \beta = T v p \alpha^2 / (J \alpha / \beta).$$

From the values thus calculated for water at 0° , it is seen that C/c approximates closely to unity. This result is not in agreement with the values of C/c previously calculated from the formula for the velocity of sound $V = \sqrt{(C\beta/p\alpha)}$; in the latter case the ratio α/β was taken as constant, whereas it varies considerably with the pressure. T. H. P.

268. Latent Heat of Fusion. G. Tammann. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 8. pp. 885-886, 1918.)—The latent heat of fusion r_p is made up of five components—

- A_e = Work done against external forces.
- A_i = Work done against internal forces.
- ΔE = Difference of energy of molecules in isotropic and anisotropic state.
- $\Delta \Pi$ = Difference of energy of irregular and regular molecular arrangement.
- $\Delta x W_e$ = Heat-change accompanying association or dissociation, where W_e is the heat of association and Δx the change in the association factor on fusion.

At high-pressures a max. melting-point often occurs. At this point there is no change of volume on fusion; therefore A_e and A_i disappear, and $r_p = \Delta E + \Delta \Pi$.

The Crompton-Walden rule that $Mr/T = \text{const.}$ [where M = mol. wt., r = latent heat of fusion, T = melting-point (abs.)] is of doubtful validity, since out of 157 substances tabulated only 87 give values for the constant falling within the limits 15.8 to 12.0 suggested by Walden. It is suggested that this rule can scarcely apply to those components A_e and A_i of the latent heat which depend on the change of volume on fusion, nor to the components ΔE and $\Delta \Pi$ which depend on the nature of the space lattice of the crystals, etc. But the two former components and the two latter only account for about 10 + 10 % of the latent heat, and larger deviations than 20 % from the Crompton-Walden rule would imply large changes in the final component $\Delta x W_e$ which depends on changes of association. This is confirmed by a comparison of the Crompton-Walden constant with the association or dissociation of the melt as deduced from Eötvös' temperature-coefficient of molecular surface energy or Walden's modified application of it. Dissociated liquids give constants ranging from 15.8 up to 128; associated liquids give constants ranging from 11.5 to 2.8; all substances giving intermediate

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constants are normal, so far as they have been examined, but normal liquids may also give lower constants down to 2·0 ; the metals give constants ranging from Bi 4·82 to K 1·84.

T. M. L.

269. Vapour Pressures and Thermometry at Low Temperatures. H. v. **Siemens.** (Ann. d. Physik, 42. 4. pp. 871-888, Nov. 4, 1918.)—The paper describes a suitable form of vapour-pressure thermometer for low-temperature work, the instrument being a modified form of that devised by Stock and Nielson [see Abstract No. 662 (1907)]. The vapour pressures of CS_2 , CO_2 , O, and N are carefully determined at various temperatures by the use of suitable baths, the temperatures of which are measured by means of a Pt-resistance thermometer. This latter is calibrated by means of the observations of Onnes and Clay [see Abstracts Nos. 279 and 280 (1907)] and the Nernst reduction formula for different specimens of Pt. The observations of vapour pressure are compared in a series of tables with those of other observers, as are also the values of the latent heats calculated from them by means of the formulæ of Nernst and Berthelot.

F. J. H.

270. Vapour Pressures of Substances of Low Critical Temperature at Low Reduced Temperatures. I. **Carbon Dioxide between -160°C . and -188°C .** H. K. **Onnes** and S. **Weber.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 215-227, Oct. 24, 1918. Communication No. 187b from Phys. Lab., Leiden.)—The authors have undertaken a series of determinations of vapour pressures for substances of low critical temperature at lower temperatures than in previous determinations. The measurement of the very low vapour pressures dealt with requires special methods. In measuring the pressure in a space at the ordinary temperature and connected by means of a tube with the space where the vapour and liquid (or solid) are in equilibrium at a known low temperature, correct results are obtainable only if due regard is paid to the theory of the thermal molecular pressure. This theory has been developed by Knudsen [Abstract No. 665 (1910)], who showed that, when a temperature gradient exists along a closed tube containing a gas in equilibrium, there will in general be a pressure difference between the ends of the tube, the higher pressure being observed where the temperature is higher. Pressures between 1 and 0·01 mm. have been measured by Knudsen's heated wire gauge [Abstract No. 1180 (1910)] and those between 0·01 and 0·001 mm. by Knudsen's absolute manometer [Abstract No. 1817 (1911)]. By means of the latter, the vapour pressure of CO_2 between -188° and $-167\cdot08^\circ$ has been measured, the numbers agreeing satisfactorily with those calculated according to Nernst's formula with the constants determined by Falck [Abstract No. 1656 (1908)]. Measurements made with the heated wire gauge in the neighbourhood of -168° gave one result agreeing well with those obtained with the absolute manometer, and a second which seems to be rather too high, this being due probably to uncertainty in the temperature with the absolute manometer.

T. H. P.

271. Vapour Pressures at very Low Reduced Temperatures. II. **Vapour Pressure of Carbon Dioxide from -140° to about 160° .** S. **Weber.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 445-454, Nov. 27, 1918.)—These measurements were made with the heated wire manometer previously described [see preceding Abstract], the corrections to be applied being calculated by means of Knudsen's formulæ [Abstracts Nos. 665 (1910) and 499 (1911)]. The observed results are compared with those calculated from

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Nernst's vapour-pressure formula, in which the coefficients of $1/T$ and T are given values differing slightly from those of Falck [Abstract No. 1656 (1906)] in order to obtain satisfactory agreement at the higher pressures: $\log p = -6007.9/4.571T + 1.75 \log T - 0.009008T/4.571 + 8.1700$. This formula does not give good results at temperatures much higher than -184° , the calculated and observed pressures at -129° exhibiting considerable divergence.

T. H. P.

272. *Isothermals of Monatomic Substances and their Binary Mixtures.* XV. *Vapour Pressure of Solid and Liquid Argon from the Critical Point down to -206° .* C. A. Crommelin. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 477-485, Nov. 27, 1918. Communication No. 188c from Phys. Lab., Leiden.)—The author gives the completed results, some of which have been previously published, of all his observations concerning the vapour pressure of solid and liquid argon. The boiling-point under atmospheric pressure is found by linear interpolation to be -185.84°K. , and the triple point, which is difficult to determine owing to supercooling phenomena, lies at -189.80°K. , the density of solid argon being then greater than that of the liquid. The experimental values of the vapour pressures are in moderately good agreement with those calculated from Rankine and Bose's formula, especially for the liquid-vapour region. In the case of solid-vapour, better correspondence with the experimental results is given by Nernst's vapour-pressure formula, $\log p = A/T + BT + D \log T + c$, the four coefficients being regarded as empirical and of no theoretical significance; in the field of liquid-vapour this formula is capable of representing the observations as far as the critical point in a fairly satisfactory manner and, in many cases, where the accuracy required is not very great, may be a convenient help in calculation. Moderately good agreement for solid-vapour is also shown by Sackur's formula [Abstract No. 880 (1918)]. The values of (dp/dT) at the triple point are calculated to be 0.08162 and 0.08628 for vapour-liquid and vapour-solid respectively. The heats of evaporation at a number of different temperatures are calculated from the Clapeyron-Clausius equation.

T. H. P.

273. *Reversible Adiabatic Expansion of Water.* J. R. Roebuck. (Phys. Rev. 2. Ser. 2. pp. 299-306, Oct., 1918.)—For the success of the determination of the mechanical equivalent of heat by the porous plug method [see Abstract No. 1971 (1913)] it was necessary to adjust the conditions such that no temperature-change would occur in a free expansion. Experiments are now described by which, with slight modifications of the same apparatus, these conditions were fully investigated. A better form of manometer was found to be necessary; accordingly a rotating piston differential manometer was designed and is fully described in the paper. For the particular pressure-change for which the gauge used in the mechanical equivalent determinations was suitable, the temperature 8.59°C. was found to be that at which there was no change of temperature with change of pressure. An attempt was also made to test whether the pressure-temperature relations for the max. density of water could be accurately obtained by this method, but the results were found not to be so reliable as direct volume measurements.

F. J. H.

274. *Vapour Pressure and Density of Oxygen.* F. E. E. Germann. (Phys. Zeitschr. 14. pp. 857-860, Sept. 15, 1918.)—Oxygen was compressed by means of a Cailletet pump and cooled by means of liquid air and charcoal.

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Its temperature was determined from the resistance of a coil of lead wire wound with tissue-paper insulation on a cylindrical block of copper containing the liquefaction tube. The pressures of the oxygen-vapour were measured by means of a standardised precision manometer. The purity of the oxygen was guaranteed by the constancy of the pressure during liquefaction. The author gives tables of vapour pressures and densities of the liquid oxygen, of which the following figures form an extract :—

Temp. deg. abs.	Pressure.	Density.
91.51	878.2 mm.	—
92.72	892.8 "	—
100.25	2.72 atm.	1.0605
112.88	7.16 "	0.9929
130.03	17.57 "	0.8662
136.10	23.59 "	0.8474

Lead has over Pt the advantage of a very regular variation of resistance at low temperatures. E. E. F.

275. Critical Data of Hydrogen. F. Bulle. (Phys. Zeitschr. 14. pp. 860–862, Sept. 15, 1913.)—The author adapted the apparatus used by Germann [see preceding Abstract] to the case of hydrogen by lengthening the liquefying tube and substituting a silver block for a copper block. This reduced the conduction to the exterior and increased the constancy of the temperature owing to the greater thermal capacity of the larger block. The results show that the boiling-point of liquid hydrogen is at a temperature of 20.48° abs. At 25.85° the pressure is 8.90 atmos., and at 31.85° it is 10.78 atmos. The critical temperature is 31.95° abs., and the critical pressure is 11.0 atmos. E. E. F.

276. Cooling Method of Drying Air for Liquefaction. G. Claude. (Comptes Rendus, 157. pp. 466–469, Sept. 15, 1913.)—The method previously used by the author for extracting water from air to be liquefied [see Abstract No. 258 (1910)] is open to the objection that traces of alcohol may accumulate in the receiver. By a suitable modification of his liquefying machine he is now able to extract the water without the addition of a foreign substance. The compressed gas is made to travel upwards instead of downwards, so that the condensed water-vapour flows back to the warmer parts of the tube, where it can be drained off, instead of forward to the colder parts, where it would freeze and block the tube. This modification, alone, however, renders the apparatus useless for higher compressions than 2 or 3 atmos., as the gas has to flow up a vertical tube in the direction of increasing density. This increase in density is considerable at the higher pressures, and the velocity correspondingly small. By sending it up the spiral tube, however, and letting the expanded gas descend by way of the central vertical tube, this difficulty is avoided. A large percentage of the water is removed in this way; the remainder, which collects in the tubes as frost, is inappreciable and allows of efficient working for upwards of 15 hours. F. J. H.

277. Critical Temperature of Mercury. A. W. C. Menzies. (Amer. Chem. Soc., Journ. 35. pp. 1065–1067, Sept., 1913.)—In view of the appearance of
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ance of Königsberger's paper [Chem. Zeit. 185. p. 1821, 1912] the author gives his own results. When mercury is heated in exhausted and sealed quartz glass tubes of 2 mm. bore in a muffle, the liquid phase is observed to disappear at 1275° , but such disappearance is due, not to attainment of the critical temperature, but to blowing-out of the quartz tube with consequent enlargement of its volume. Quartz glass is, indeed, a supercooled liquid and the vapour pressure of mercury at 1275° is in the neighbourhood of 675 atmos. Königsberger's statement that the critical temperature lies at about 1270° is regarded as incorrect.

The relation, $\alpha = 1/(2T_c - T)$, deduced by Davies [Abstract No. 1898 (1912)] indicates the critical temperature of mercury to be above 2800° and a similar value is given by Thorpe and Rücker's relationship, $T_c = (T_1 s_1 - T_2 s_2)/A(s_1 - s_2)$, where s_1 and s_2 are the densities of the liquid at the temperatures T_1 and T_2 . Guldberg's rule connecting critical temperature and boiling-point is clearly inapplicable in this case, as it rests ultimately on the assumption that the critical pressures of all substances are nearly identical. T. H. P.

278. Critical Constants of Methane. E. Cardoso. (Archives des Sciences, 86. pp. 97-100, Aug., 1918.)—In continuation of his work on the critical data of readily liquefiable gases [see Abstract No. 1728 (1912)], the author has made similar determinations with methane. The apparatus used consists of a double-walled vessel which contains a liquid freezing with difficulty, such as pentane or a mixture of ether and toluene, and is immersed in a non-silvered Dewar flask charged with liquid air or oxygen. The jacket of the inner vessel is filled with hydrogen the pressure of which can be varied in order to regulate its heat-conductivity. With such an apparatus, temperatures may be maintained constant to within 0.05° . The methane examined was previously purified chemically and then fractionated in a vacuum. The critical temperature is found to be -82.85° (190.15° abs.) and the critical pressure 45.60 atmos. The critical density, determined by extrapolation from the densities of the co-existing phases over a considerable range of temperature, is 0.1628. T. H. P.

279. Internal Pressures of Liquids. A. P. Mathews. (Journ. Phys. Chem. 17. pp. 608-628, Oct., 1918.)—The author has calculated the values of the internal pressures, or, more accurately, those of the constant a of van der Waals' equation [see Abstract No. 1096 (1918)], for a number of liquids. These values have been derived in the following five ways: (1) From the surface tension, on the assumption that the depth of the surface layer is $[T_c/(T_c - T)]^{2/3}$ molecular diameters. (2) From the law of Eötvös and T. Young. (3) From van der Waals' equation, applied to the critical temperature, assuming that b_c is always $2V_c/3$, S being equal to $RT_c/V_c P_c$. (4) From the internal latent heat of vaporisation close to the critical temperature. (5) From the molecular weight and the number of valencies per molecule, according to the formula $a = 1.259 \times 10^{11} (M \times \text{Val})^{2/3}$. These methods give practically identical results, and with pentane and ether the values of a are found to be constant over a wide range of temperature, so that, unless there is association, a is constant. The values obtained are uniformly higher than those computed by others, with the exception of those recently derived by Lewis [Abstract No. 645 (1912)] from the values of the latent heats of expansion of liquids. The numbers given by Traube, Walden [Abstract No. 862 (1910)], and Davies [Abstract No. 1915 (1912)] are too low and inaccurate in other ways. The author's results confirm his conclusion

that the molecular cohesion is a function of the molecular weight and of the number of valencies in the molecule. The formula $a = 27T^3/64 \times 278^2P$, gives values about 14 per cent. too low for ordinary substances and very much too low for simple diatomic gases; it should be replaced by the formula, $a = (S^2 - S + 2)T^3R^2/S^2(S - 2)P$. The results show also the inaccuracy of Stefan's conclusion, that the work required to bring particles from the interior of a liquid to the surface is equal to one-half of the work required to vaporise these particles (Wied. Ann. 29. p. 655, 1896). T. H. P.

280. Combustion of Gaseous Mixtures. Taffanel and Le Floch. (Comptes Rendus, 157. pp. 595-597, Oct. 18, 1918.)—In continuation of their previous work [Abstract No. 1448 (1918)], the authors have now determined the velocities of reaction of gaseous mixtures at temperatures below that of ignition. With air containing 6.5 per cent. of methane, the amounts of the latter burnt per sec., calculated as percentages of the mixture, are as follows: at 585°, 0.00075; at 560°, 0.0016; at 575°, 0.0025; at 600°, 0.0087; at 615°, 0.0075; at 620°, 0.0145; at 680°, 0.017; at 685°, 0.021, and at 640°, 0.050. The relation between these amounts ($da/d\theta$) and the temperature, θ , is expressed by the formula: $\log da/d\theta = (\theta - 890)/70$. For mixtures containing 9 per cent. of methane and temperatures of 550-680°, the expression becomes $\log da/d\theta = (\theta - 870)/60$, and for those containing 12 per cent., $d\alpha d\theta = (\theta - 880)/50$. Similar equations are obtained for air containing either 25 or 50 per cent. of CO. The limits of inflammability have also been investigated. The temperature at which the velocity of reaction with methane-air mixtures first becomes sufficient to result in the propagation of flame is about 1810°.

T. H. P.

281. Combustion of Gaseous Mixtures and Velocities of Reaction. Taffanel. (Comptes Rendus, 157. pp. 714-717, Oct. 27, 1918.)—By means of the results previously obtained [see above], the author has made calculations of the velocities of reaction of gaseous mixtures at various temperatures. T. H. P.

282. Some Properties of Explosive and Combustion Waves. E. Jouguet. (Comptes Rendus, 157. pp. 545-547, Oct. 6, 1918.)—The paper is a mathematical discussion of the results acquired when a gaseous mixture capable of interaction passes from one state of known specific volume, absolute temperature, pressure, and degree of combustion, to another. The various states are represented graphically, and the curves obtained receive detailed study. In a previous paper [Abstract No. 1292 (1910)] the author has shown that certain waves should be propagated with a velocity lower than that of sound, and in consequence he has doubted their possibility. In the present paper the author admits his doubts to be a trifle exaggerated, and proceeds to demonstrate the importance of such waves from the standpoint of wave alteration during the course of propagation when limiting conditions are inadequate. These waves are now shown to have bearing on the theory of deflagrating explosions. The latter connection then receives detailed attention, and, as a result, it is found that the product of the speed of the explosive wave and that of slow deflagration is less than the square of the velocity of sound. This relation between three interesting speeds is a trifle loose since it is expressed by an inequality, although it merits special notice. It has been verified for oxygen and hydrogen, where the velocity of sound is 520 m. per sec., that of the explosive wave 2810 m., and that of deflagration about 20 m.

H. H. Ho.

283. *Condensation of Water-vapour by Supersaturation.* L. Besson. (Le Radium, 10. pp. 818-828, Oct., 1918.)—The author has repeated the experiments of C. T. R. Wilson on the amount of supersaturation necessary for water-vapour to condense on positive and negative ions. A slightly modified apparatus was used permitting the gas under observation to be easily varied. Experiments were made with methane, CO_2 , and air, the results showing that condensation depends on the degree of supersaturation and not on the nature of the gas. Photographs of the clouds formed under different circumstances are given. E. M.

284. *The Partition of Energy.* J. D. van der Waals. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 401-408, Nov. 27, 1918.)—In the author's previous papers [Abstract No. 1981 (1918)] no zero-point energy was assumed. To assume zero-point energy leads to great difficulties, attributed by the author to the necessity of assuming that incident radiation sets the electron in vibration; for this would make the elementary process of absorption irreversible, whereas the co-operation of many such is observed to originate reversible phenomena. Yet, as Planck has noted [Vorlesungen über Wärmestrahlung, 2nd ed., p. 140], radio-activity can hardly be even qualitatively accounted for without assuming zero-point energy, owing to its observed independence of temperature. The presence in the atom of particles vibrating with high enough frequencies would neither give rise to radiation nor contribute to the specific heat, and with different frequencies, phases, and amplitudes, the latter varying from 0 to $8h$, an unstable configuration might occur, and therefore a radio-active explosion. But to assume the presence of such particles without connection with the zero-point energy would appear too arbitrary. The homogeneity of the β -rays from a radio-active atom, observed by Hahn and Meitner and by O. v. Baeyer, might be explained by assuming that a particle vibrating with period 8 in the atom is emitted with energy $8h$, in which case there would be close correspondence between radio-active and photoelectric phenomena, emission in the latter case arising from incident radiation, and in the former from co-operation of intra-atomic motions. The internal vibration frequency for β -rays for which $v = 0.92 c$, would then have to be $\nu = 8.25 \times 10^{10}$. Sommerfeld's value for λ [Congrès Solvay p. 842, 1911], in the case of γ -rays corresponding to β -rays of this velocity, is $\nu = 5 \times 10^{10}$, slightly higher than corresponds to the wavelength of the corresponding γ -rays. This extremely high frequency would satisfactorily explain the observed independence of radio-activity on temperature. G. W. DE T.

285. *Enumeration of Vibrations of Solids.* R. Ortway. (Ann. d. Physik, 42. 4. pp. 745-760, Nov. 4, 1918.)—A treatment of the kinetic theory on the quantum hypothesis with respect to the specific heats of solids. The formula of Debye, according to which the number of proper vibrations increases as the third power of the frequency, is thus extended to crystals as far as the rhombic system. [See Abstract No. 446 (1918).] E. H. B.

286. *Radiation and Specific Heat.* H. L. Callendar. (Phil. Mag. 26. pp. 787-791, Oct., 1918.)—The paper consists of notes explanatory of points raised in the author's address to Section A of the British Association in 1912. He suggests that the difference between his own theory and Planck's appears to originate mainly from the assumption of the latter for the entropy relation, $TdG = dE$, in place of the usual $dE + pdv$. The author's VOL. XVII.—A.—1914.

theory accounts for the otherwise unexplained fact that some simple substances, such as water and mercury, show a diminution of specific heat with rise of temperature. Values for the specific heats in good agreement with experiment, at the temperature of liquid air, are obtained when the mean frequencies for the Rest-strahlen for rock-salt and sylvin are inserted in the formula derived from his theory. They are somewhat lower than those observed in liquid hydrogen, and slightly higher than those observed at higher temperatures; this, however, may be explained by supposing that the resonance is not sharply confined to a single frequency, but extends over an appreciable range. The failure of the formula deduced by Einstein from Planck's theory to give correct values of the specific heats when the Rest-strahlen frequencies are assumed may be due to its not taking explicit account of the ρv term in the total energy, which, the author points out, is seldom, or never, mentioned in the theory of radiation, except in the deduction of the fourth-power law, where it is universally admitted.

G. W. DE T.

287. Relation of the Volume-surfaces to the Polymorphism of Water. G. Tammann. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 157-176, 1918.)—Whilst 5 modifications of ice are known, some of them perhaps existing in more than one variety, the author finds in the p, v, T surface for water traces of six kinds of molecules, of which the last might perhaps crystallise at extremely high pressures and relatively high temperatures.

T. M. L.

288. Equation of State of an Ideal Monatomic Gas according to the Quantum Theory. W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 227-236, Oct. 24, 1918. Communication No. 80a from Phys. Lab., Leiden.)—Debye [Abstract No. 446 (1918)] has shown that agreement with the observations concerning the specific heats of solid substances can be obtained by modifying Einstein's theory by application of the formula given by Planck for the mean energy of a linear electrical oscillator at the temperature T to the different principal modes of vibration of a solid. The author suggests the application of the same principle to other material systems capable of functioning as oscillators, and hence the investigation of the accuracy of the consequences of the hypothesis that Planck's principle of finite elements of energy holds for each principal mode of vibration of an oscillator with motions definable by linear differential equations, no matter what the constitution of the oscillator. In the present paper these consequences are deduced for an ideal monatomic gas, with reference to the divergence from Boyle's law, the variation of the specific heat, etc.

T. H. P.

289. Constant of the Stefan Radiation Law. W. H. Westphal. (Deutsch. Phys. Gesell., Verh. 15. No. 19. pp. 897-902, Oct. 15, 1918.)—The paper describes further measurements of the constant of Stefan's radiation law which were considered necessary by reason of the fact that recent determinations by Puccianti and by Keene [Abstracts Nos. 1858 (1912) and 688 (1913)] are higher than the value previously obtained by the author [Abstract No. 460 (1913)]. The original apparatus was modified in certain particulars and the observations were extended over a wider range of temperature with a view to increasing the accuracy. The value obtained for the constant, 5.57×10^{-12} , agrees remarkably well with the earlier determination, viz. 5.54×10^{-12} .

F. J. H.

SOUND.

290. Gramophone Improvements. A. A. Campbell Swinton. (Nature, 91. p. 558, July 31, 1918.)—Describes improvements to a gramophone of the cabinet pattern which have practically eliminated the scraping noises. The lid at the top has a felt seating. The sound passes through the usual movable arm into about 14 ft. of 2-in. flexible steel pipe in six vertical lengths to the trumpet. The bends in the pipe (as in De la Rue's machine) are made of zinc, and it appears to be these bends which chiefly eliminate the scraping noises. The trumpet is of the *donkey's-ear* pattern due to S. G. Brown, and is made of four flat pieces of three-ply Birch fretwork wood of $\frac{1}{8}$ -in. total thickness. It has an oblong mouth and is shaped with *different lengths at top and bottom*.
E. H. B.

291. Vibrations of Telephone Membranes. I. M. Siegbahn. (Ann. d. Physik, 42. 4. pp. 689-728, Nov. 4, 1918.)—Two methods are used to obtain photographic records of the motions of telephone membranes. In the first a cork communicates the motion of the telephone membrane to that of a manometric capsule, the flame from which is photographed. In the second, light is reflected from a small concave mirror attached to the telephone membrane at its place of greatest angular change. This light is received on a fixed plane mirror, a second time reflected from the moving concave mirror and then focused on a moving photographic film so as to yield a graph of the vibration. Besides many figures and tables of observations there are nine full-page plates showing the records of the various vowels. The paper includes also a theoretical treatment of the vibrations in question.
E. H. B.

292. Sound Effects on Passage of Alternating Currents at the Contact of Metal Point on Crystal, etc. R. Dongier and C. E. Brazier. (Comptes Rendus, 157. pp. 587-589, Oct. 18, 1918.)—Reports an examination as to the effect of various pressures or various substances on the sounds emitted at the contact of a metallic point and crystal or another metal when used as the detector in radio-telegraphy. As to pressure, the max. sound is obtained for a certain medium value between extremes of pressure. As to materials, ordinary steel, nickel steel, German silver, manganin, nickel, and brass were put successively in contact with the same crystal and pressed so as to obtain the max. sound; but the difference between one material and another was not well marked. Manganin was best.
E. H. B.

293. Sound Intensity of the Singing Arc. H. Lichte. (Ann. d. Physik, 42. 4. pp. 848-870, Nov. 4, 1918. Extract of Dissertation, Göttingen.)—An experimental research of which the following are the chief conclusions:—The Rühl law as to the dependence of sound intensity on arc length, on alternating and direct current strengths, for the frequencies 220-846 was confirmed and extended. The sound intensity is proportional to the square of the arc length and to the square of the alternating-current strength. For constant arc lengths and constant alternating currents the sound intensity is proportional to the p.d. at the arc. The dependence of the sound intensity on the diam. of the carbons reaches a minimum for a certain diam. This minimum diam. depends on the arc length and current. The dependence
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of the sound intensity on the frequency involves the square of the latter up to frequencies of 500, but for higher frequencies the fourth power is involved also.

E. H. B.

294. Origin of Combination Tones in Microphone-Telephone Circuit. **E. Waetzmann.** (Ann. d. Physik, 42. 4. pp. 729-744, Nov. 4, 1918.)—The author concludes that the origin of the combination tones observed in the microphone-telephone circuit is to be referred to the kind of resistance-change of the microphone under the influence of several primary tones, and has little or nothing to do with Helmholtz's theory, though that may still be valid for combination tones afterwards formed in the ear itself. [See Abstracts Nos. 867 (1909) and 649 (1918).]

E. H. B.

295. Absorption of Sound by Various Materials. **H. O. Taylor.** (Phys. Rev. 2. Ser. 2. pp. 270-287, Oct., 1918.)—For this experimental research the steady source of sound adopted was an organ-pipe with air from a chest. As this sound had overtones which were not desired a second screen or filter was employed to absorb them. This consisted of side pipes in resonance with the tones to be absorbed. The fundamental tone of the pipe then passed on in a chamber to the substance under test, and was partially absorbed and partially reflected. There are thus produced a set of stationary waves whose minima are not zero. An examination of the ratio of the maxima and minima of these waves gives the required clue to the amount reflected, and consequently to that absorbed.

As a quantitative detector for these sounds various instruments were tested, including telephones, galvanometers, molybdenite and silicon rectifiers, barretters, and microradiometers. The Rayleigh disc was finally adopted as the most trustworthy and sensitive sound-measuring instrument. The disc used was of mica, 1 cm. in radius, suspended by a quartz fibre about 10 cm. long, a small mirror being fixed to it. The disc was hung in a little wooden box with a glass front, and two 1-in. glass tubes led into opposite sides of the box. These tubes were stopped with corks so as to be in resonance with the sound in use. A $\frac{1}{4}$ -in. glass tube about 8 ft. long (adjusted to resonance with the pitch in use) pierced one of the corks and served to deliver the sound energy to the disc. The Rayleigh disc, thus mounted, was then used to explore the quasi-stationary waves.

Some results obtained are as in the table:—

Material.	Coefficient of Absorption.
Smyrna rug	0.26
Brussels carpet	0.28
Hair felt (1 in. thick).....	0.51
Ceclinite ($\frac{1}{4}$ in. thick).....	0.25
Asbestos roll fire-felt ($\frac{3}{4}$ in. thick)	0.26
Compressed cork ($1\frac{1}{4}$ in. thick)	0.82

Other researches are projected along the same or similar lines.

E. H. B.

296. Vibrating Strings Analogous to Loaded and Unloaded Telephone Cables. **J. A. Fleming.** (Phys. Soc., Proc. 26. pp. 61-74; Discussion, p. 74, Dec., 1918. Electrician, 72. pp. 786-787, Feb. 6, 1914. Abstract.)—The problem of determining the possible vibrations of a loaded string, that is, a flexible string having small masses attached to it at equal distances, is one to which many mathematicians have given attention. Among these are Lagrange, Rayleigh, and C. Godfrey [see Abstract 905 (1898)].

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Recently the matter has acquired an electrical interest from the close analogy existing between the transmission of mechanical vibration along a loaded string and the propagation of alternating electric currents along a telephone cable having inductance coils inserted in it at equidistant intervals. In seeking for experimental methods of illustrating the properties of such loaded cables it was natural to turn for assistance to the visible oscillations produced on strings loaded or unloaded. To produce such vibrations the elegant device of F. E. Melde (in which one of the prongs of a tuning-fork sets in motion one end of the string) suffers from the following objections :—(1) A considerable tension on the string will stop the fork even if electrically driven ; (2) With long loaded strings large forks are needed to provide a low enough frequency ; (3) Any desired change of frequency needs a change of the fork ; (4) The vibrations of the string occur only in one plane, and are not plainly visible unless viewed from a certain standpoint. The author accordingly discarded the Melde arrangement for the present purpose, devising instead the following, which proved satisfactory. On the shaft of an electric motor of $\frac{1}{2}$ to $\frac{1}{4}$ h.p. is attached a disc carrying a crank-pin describing a circle about 1 in. in diameter. This pin is connected by a rod to a rocking lever, the connecting rod having a hook near each end. Thus by attaching one end of the string to either of these hooks we may give to the string a circular motion or a simple harmonic motion, and the latter may be arranged either longitudinally or transversely. The motor is fitted with a counting arrangement so as to admit of the ready adjustment of its frequency. The remote end of the string is attached to a pin with longitudinal screw traverse for adjustment of tension which is indicated by a spring balance.

This method of excitation of vibrations shows beautifully the stationary vibrations of an ordinary or unloaded string and the quite similar ones when the loads are three or more to the wave-length. The attempt to produce waves so short as to have only two loads or less per wave-length shows clearly that the waves penetrate but a small distance from their source, there being a reflection from each of the loads which soon absorbs all the energy. The reflection of waves from the junction of parts of the string with different masses per unit length is also clearly shown. The paper includes the mathematical development of the subject, and photographic reproduction of five interesting cases of the stationary waves. E. H. B.

297. *Sounding Board in Auditorium.* F. R. Watson. (Brickbuilder, 8, pp. 1-6, June, 1918.)—Describes with seven perspective views and sections the special sounding board designed and made to improve the acoustics of a given auditorium. The shape of the reflector was a quarter section of a paraboloid of revolution with the axis nearly horizontal. The frame was made of wood, and faced on the under side with hard plaster on wire lath. For a speaker confined to a small region this reflector distributed much of the sound over the audience and thus avoided the objectionable echoes produced when the sound passed freely to the walls. [See Abstract No. 1580 (1911).] E. H. B.

298. *Plane Waves of Sound.* J. R. Wilton. (Phil. Mag. 26, pp. 440-452, Sept., 1918.)—It is well known that the exact equation for plane waves of sound leads to a result which cannot hold beyond a certain time, owing to the fact that the motion becomes discontinuous. It is here shown that the ordinary approximate solution, in which the displacement is regarded as a small quantity whose square may be neglected, does not begin to depart
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widely from the truth until the motion approaches the stage in which it becomes discontinuous. The mathematical investigation then follows from which these results emerge :—For a low note, just audible (say of frequency 80, and amplitude 10^{-6} cm.) motion of the air is such that viscosity and other influences will cause the motion to cease long before discontinuity sets in. But a high, loud note, on the other hand, gives rise to a motion which instantly becomes discontinuous. (The example worked is for a frequency of 8500 and amplitude 10^{-2} cm.)

E. H. B.

299. Propagation of Sound in a Heterogeneous but Non-absorbing Fluid. **M. Brillouin.** (Comptes Rendus, 157. pp. 1185–1188, Dec. 8, 1918.)—A mathematical discussion showing that it is not the flux of the potential energy U which is conserved, but the product $(\Omega^2 U \div \Omega_\phi)$, where Ω is the velocity of the sound and Ω_ϕ denotes what is called the velocity of the phase.

E. H. B.

300. Musical Scales. **A. Vaucher.** (Archives des Sciences, 86. pp. 189–168, Aug. ; 289–257, Sept., and pp. 884–856, Oct., 1918.)—An elaborate examination, both mathematical and musical, of the scale and its possible temperaments. In particular the cycle of 58 commas to the octave is very fully discussed. But it is concluded that the tempered scale of 12 equal intervals is after all the most logical, the most mathematical, and that which, all things considered, responds best to the musical sentiment.

E. H. B.

301. Pianoforte Touch. **G. H. Bryan.** (Nature, 92. pp. 292–293, Nov. 6, 1918.)—A reply to S. Pickering in which the present author expresses a preference for holding the wrists high above the keyboard for a brilliant tone and right below the keyboard for a soft tone. [See Abstracts Nos. 1177 and 1851 (1918).]

E. H. B.

302. Sound Selection by Microtelephone. **H. Zwaardemaker.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 194–198, Oct. 24, 1918.)—By means of a Rayleigh disc the response to the voice is noted for each semitone through a range of an octave and a half, (1) without, and (2) with a microtelephone. With telephone diaphragms of different thicknesses the responses at various pitches (or tone-selections) differ widely. It is hoped that by a continuance of the researches it may be possible to supply a corrective augmentation of sound at the pitches for which a patient's hearing is defective.

E. H. B.

303. Hearing Apparatus examined by the Rayleigh Disc. **H. Zwaardemaker.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 492–498, Dec. 27, 1918.)—The author considers that before trying to find a suitable apparatus for defective ears, it is necessary to ascertain its auditory range in the zone a_1 to e_1 . The apparatus has then to supply the deficiency of the organ in this region. In the experimental part of previous researches the author used a microphone and a string galvanometer. He now adopts the Rayleigh disc and considers it unquestionably better.

E. H. B.

304. Sum of Sound Intensities in Binaural Localisation. **G. W. Stewart.** (Phys. Rev. 2. Ser. 2. pp. 72–76, July, 1918.)—Considers the sum of intensities received at each ear as a factor in practical localisation of a source. It is shown by curves that this change of sum of intensities changes with the turning of the head through given angles, and changes differently for sounds of different pitches.

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

305. *Free Electrons in Metals*. W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 16, pp. 286-245, Oct. 24, 1918. Communication No. 80b from Phys. Lab., Leiden.)—It seems natural to transfer to the theory of free electrons in metals the considerations of the former paper regarding the application of the quantum theory to the equation of state of an ideal monatomic gas. The frequencies in an electron gas, with the same order of magnitude of the number of particles per unit of volume, become very much higher than in the ordinary material gases. Hence the limiting laws deduced for low temperatures may be valid for a system of free electrons up to much higher temperatures, possibly even throughout the region which can be used experimentally. The consideration of the dynamic equilibrium between the free electrons and the electrons within the molecules of the metal leads to the supposition that at low temperatures the number of free electrons per unit of volume approaches to a constant finite value. The same is then the case for the mean velocity of the free electrons. In this manner the application of the quantum-theory to the free electrons in a metal leads, for low temperatures, to the suppositions, regarding velocity and density of electrons, on which Wien recently based his theory of electric conduction, in which theory, as previously by K. Onnes and by Lindemann, the quantum hypothesis is applied to the molecular oscillations which impede the motion of the free electrons. On the other hand, the application of the quantum-theory to the free electrons leads, for high temperatures, to the theory of free electrons in metals in the form in which it has been developed by Riecke, by Drude, and by Lorentz, and which may be called the equipartition theory. Hence the quantum-theory appears to be able to unite both the theories mentioned into one simple and coherent whole. By it, at the same time, two great difficulties, which were inherent in the equipartition theory, are solved. In the first place, it does not follow any more, as was assumed on the equipartition theory, that on approaching $T=0$ the electrons all "freeze down," a phenomenon contradicted by the observations of K. Onnes down to the lowest temperatures at which electric conductivity has been investigated. The application of the quantum-theory given here again allows us to consider the equilibrium between the free electrons and those within the molecules as a dissociation equilibrium in the way emphasised by Koenigsberger for the theory of electric conductivity. Secondly, the difficulty disappears which on the equipartition theory followed from the small contribution made by the free electrons to the specific heat of the metal, a difficulty which appears even more sharply in the theory of the Thomson heat as pointed out by Oosterhuis.

The present author then deals mathematically with the thermoelectric power, the Peltier-effect, and the Thomson-effect. It is shown that each of these decreases to 0 for $T=0$, the thermoelectric power and Thomson-effect finally decreasing as the cube, and the Peltier-effect as the fourth power, of the temperature. [See Abstract No. 1465 (1908).] E. H. B.

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306. Flux of Electrical Energy. **M. Siegbahn.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 81. pp. 1-21, and 9. No. 1. pp. 1-16, 1918.)—Mathematical treatment of various electrical problems on the basis of Maxwell's equations, Poynting's theorems, and the principle of relativity.

E. H. B.

307. Electrical Units. **P. Janet.** (Soc. Int. Élect., Bull. 8. Ser. 8. pp. 950-958, Nov., 1918.)—A statement of the relations which exist between the absolute and international electrical units, and the degree of agreement between the electrical standards of different countries. The international ohm is stated to be equal to 1.00040 ohms; the international ampere to be 0.99996 amps.; and the international volt to be 1.00086 volts. [From the references given by the author the relation between the int. ohm and the ohm should be 1 int. ohm = 1.00052 ohms, the int. volt then being 1.00048 volts. (F.E.S.).] It is believed that the int. ohm and the int. ampere may be practically realised within a few parts in 100,000, and it is shown that the standards of resistance and of e.m.f. of France, of the Bureau of Standards, of the Reichsanstalt, and of the National Physical Laboratory agree also within a few parts in 100,000.

F. E. S.

308. Nomenclature and Definitions of Magnetic and Electrical Quantities. (Electrician, 71. pp. 1012-1014, Sept. 28, and pp. 1054-1057, Oct. 8, 1918. Report of Committee of the British Assoc., Birmingham, 1918.)—This report is in the form of a discussion on the present nomenclature and definitions of electrical and magnetic quantities together with some alterations which have been proposed, and some new suggestions. The original pages should be consulted.

R. E. N.

309. Pyro- and Piezo-electricity. **E. Riecke.** (Archives des Sciences, 86. pp. 101-112, Aug.; 216-238, Sept.; 305-325, Oct., and pp. 405-430, Nov., 1918.)—A series of articles chiefly mathematical, and discussing the pyro- and piezo-electricity of tourmaline, including a comparison of Voigt's phenomena with experimental data, and a molecular theory of piezo-electricity. [See Abstract No. 1285 (1912).]

E. H. B.

DISCHARGE AND OSCILLATIONS.

310. Connection between Ionisation by Collision and Electronic Affinity. **J. Franck and G. Hertz.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 929-984, Oct. 80, 1918. Paper read before the 85. Deutsch. Naturforscherversammlung, Vienna, Sept., 1918. Phys. Zeitschr. 14. pp. 1115-1117, Nov. 15, 1918.)—From work on ionic mobilities [Abstract No. 1479 (1910)] Franck has shown that different gas molecules exert different forces on electrons, i.e. in some gases the electrons have a long life duration in the free state, whilst in others they become the centres of clusters. In the present paper it is shown that information on this question is afforded by experiments on ionisation by collision. It is well known that the currents due to ionisation by collision in He are greater than those in H₂, for instance. However, the minimum energy required for an electron to ionise a molecule is greater in He (20.5 volts) than in H₂ (11.0 volts). The reason appears to be that the collision of an electron with an atom of He is almost a perfectly elastic one, so that the electron does not lose energy, whereas in the collision with a hydrogen molecule practically all the energy is lost. Experimental evidence of this is given. Ionisation is produced in pure He (or Ne) at about 1 mm.

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pressure between two electrodes. As the p.d. between the electrodes is increased beyond 20.5 volts, a point of inflection occurs in the current-potential curve, due to the production of fresh ions by collision. This shows that the energy acquired by the negative electrons between the collisions with the molecules is integrated. A further point of inflection in the curve occurs at 41, i.e. 2×20.5 volts, in further agreement with the above idea.

E. M.

311. *Instability of Gaseous Ions.* R. D. Kleeman. (Cambridge Phil. Soc., Proc. 17. pp. 268-279, Sept. 8, 1918.)—After summarising results obtained in previous papers [Abstracts Nos. 548 and 1785 (1912)], the results of further experiments are discussed, leading to the conclusions that : (1) The period of life of an elementary ion or cluster varies largely with the nature of the gas, and is largely modified by slight admixtures of other gases ; (2) the period of life of a cluster in a gas at standard pressure may have a value lying between a few seconds and a small fraction of a second. The order of magnitude of the period of life of an elementary negative ion is about 1/100 that of a cluster. The various expressions obtained by physicists for the velocity of an ion through a gas, on the assumption that it consists of an unchanging cluster of molecules, must therefore be regarded as merely useful empirical formulæ. The results also suggest a modification in the ordinary theory of ionisation by collision, as they indicate, not a current of elementary ions only, but also a current of clusters. The velocity of atomic ejection of an electron can have but little influence on the resulting ionisation by collision, as the electron will, on an average, undergo hundreds of collisions before reaching an electrode. But the direction of ejection relatively to that of the electric field will largely affect the formation of clusters. A formula is developed for calculating the life period of a positive cluster, but the absence of data precludes the deduction of any definite conclusions from it, or even as to the life period of an elementary positive ion.

G. W. DE T.

312. *Theory of Photoelectric Effect.* L. Kordysch. (Le Radium, 10. pp. 818-816, Oct., 1918.)—The paper is partly in connection with that of Debye and Sommerfeld [Abstract No. 1859 (1918)], but deals with both the normal and the selective photoelectric effect, the former being presumed to be due to free electrons and the latter to bound electrons. It is known that the selective emission depends on the angle of incidence of the polarised light. This is provided by the theory, and it is also shown in further agreement with the theory, that in the passage of light through thin films of green malachite, fuchsine, cyanine, etc., the most absorbable wave-length (λ) depends on the angle of incidence ; thus $\lambda_{70^\circ} > \lambda_{50^\circ} > \lambda_{30^\circ}$.

E. M.

313. *Absorption of Kathode Rays by Metallic Sheets.* R. Whiddington. (Cambridge Phil. Soc., Proc. 17. pp. 280-281, Sept. 8, 1918.)—In a former paper [Abstract No. 558 (1912)] the author showed that the diminution of the velocity (v) of kathode rays on passing through a thickness x of matter is given by the relation $v_0^4 - v_x^4 = ax$, where a is a constant for each material. We are thus led to a conception of a "range" of kathode rays which is obtained by putting $v_x = 0$, i.e. $d = v_0^4/a$; where d is the thickness of material through which kathode rays of velocity v_0 can just penetrate. With regard to the number of kathode rays (I) which penetrate through a sheet of matter of thickness x , Lenard has shown that $I = I_0 e^{-\lambda x}$, where λ is the absorption coefficient. The present experiments show that in the case of sheets, silver or gold, of thickness d , λ is proportional to $1/v^4$ for velocities

greater than the value of v calculated from the above relation— $d = v^4/a$. In the case of copper a peculiarity is observed in the curve $1/v^4 - \lambda$ at the point corresponding to $v = 6.2 \times 10^9$ cm. sec.⁻¹, this being the velocity above which the characteristic radiation of Cu is excited. E. M.

314. The Photoelectric Effect. K. T. Compton and O. W. Richardson. (Phil. Mag. 26, pp. 549–567, Oct., 1918.)—There are two lines of experimental investigation which have been followed in the search for the ultimate explanation of the photoelectric effect from metals. The line of investigation which has received most attention is that respecting the velocities of the emitted electrons and the relation of these velocities to the nature of the emitting metal and the frequency and intensity of the incident light. The second line of attack on this problem is the investigation of the effect of the intensity of the light, the frequency of the light, and the nature of the metal on the number of electrons emitted in unit time. The purpose of the present experiments is the investigation of the relations involved in the equation $N = Ah/R^2\nu^2(1 - e/800 \cdot w_0/h\nu)$ when $w_0 < 800/e \cdot h\nu < 0$; w_0 being the work expressed in equivalent volts done by an electron in escaping from the metal, N the number of electrons emitted per unit area, per unit time by light of unit intensity, A a constant characteristic of the metal, R the absolute gas constant reckoned for one molecule, ν the frequency of the incident light, and h is Planck's constant, 6.55×10^{-27} erg. sec. The most striking conclusion to be drawn from the results obtained is that there are two maxima in the sensitiveness-frequency curve, instead of but one maximum as indicated by the theory and by the experiments of Pohl and Pringsheim. The discovery of this second maximum is due to the use of very electro-positive metals and to the sensitiveness of the energy calibration system used, which enabled the investigation to be carried further into the ultra-violet than ever before. The experimental results indicate that the photoelectric sensitiveness is the same function of the frequency for all metals, the difference being that the curve is shifted bodily out to the region of short wave-lengths for the electro-negative metals. This function is evidently not expressed by the equation given above, which, however, accurately predicts the values λ_0 and $\lambda_{\text{max.}}$, and seems to be at least a part of the truth. That equation is only one solution of the theoretical equations, and is probably not the only or the complete solution. The results of the investigation point to the existence of another term in the solution. If this be true, the real expression of the theory should not be the equation given, but an equation in which N equals the sum of two terms. The first term would be the right member of the given equation or something very similar to it, and would provide the first maximum and account for the "selective" effect. The second term would provide the second maximum and account for the "normal" effect. The discovery of the equation of the relation between frequency and sensitiveness would be of practical as well as theoretical importance, since it would render possible the use of photoelectric cells as the most sensitive of spectro-photometers. This solution still awaits discovery. A. E. G.

315. Photoelectric Effect with Platinum Layers prepared by Cathodic Sputtering. S. Werner. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 27, pp. 1–7, 1918.)—In some experiments on the photoelectric effects with Al- and Mg-layers formed by distillation in a vacuum, R. Pohl and P. Pringsheim found that the electron emission from freshly-formed layers in vacuum

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increased with the time. This was found to be especially true for greater wave-lengths, and, at the same time, the limit of sensitivity was displaced towards the greater wave-lengths [see Abstract No. 1412 (1912)]. In the present experiments a special arrangement is devised so that all the incident light is absorbed. The Pt-layers which are formed by cathodic sputtering in nitrogen show, in vacuum, a large increase of the photoelectric effect, especially for greater wave-lengths; at the same time, the limit of sensitivity is slightly displaced towards the greater wave-lengths. With this increase of sensitivity, the connection between the photoelectric effect, for equal amounts of light-energy absorbed, and the wave-length of the light remains normal, an increase in the effect occurring with a decrease in the wave-length.

A. E. G.

316. *The Photoelectric Effect of Metallic Compounds.* G. A. Dima. (Comptes Rendus, 157. pp. 590-598, Oct. 18, 1918.)—In a previous note [Abstract No. 1824 (1918)] the author pointed out that the photoelectric power of analogous compounds of the same metal depends on the valency of the metal, decreasing with increasing valency. By repeating his experiments with a radiation source rendered more constant by the use of accumulators, he has established the same result for molybdenum dioxide and trioxide. The series of manganese oxides, viz. MnO , Mn_2O_3 , Mn_3O_4 , MnO_2 , gave a very neat illustration, for when exposed to ultra-violet light under the same conditions they emitted negative charges which may be expressed by the numbers 400, 240, 176, and 87, these being inversely as the metallic valency in the oxides. The author has made a series of comparative experiments with anhydrous and hydrated oxides, finding the best effects to be produced by the anhydrous. The case of photoelectric fatigue is next considered. The causes of the diminution of the effect with duration of exposure are not well known, and some investigators have attributed the fatigue to the presence of ozone and to gas adsorbed at the surface of the exposed body. Another explanation is that oxidation of the metal takes place in certain cases, and this would appear to be in accord with the result discovered by the author, since oxidation by increasing the valency of the metal would decrease the photoelectric effect. Therefore the higher oxides should exhibit a less fatigue than the lower. Taking the case of lead dioxide, the author found that within the limits of experimental error no appreciable fatigue could be recorded, while with lead oxide the fatigue was very rapid. Similar results were found for stannic and stannous oxides, dioxide and oxide of manganese, and mercuric and mercurous oxides. In the case of molybdenum dioxide a fatigue of 20 per cent. was found after $2\frac{1}{2}$ hours' duration, while the trioxide increased its emissivity by 25 per cent., at the same time changing in colour at the exposed parts from yellow to violet. Reduction must therefore have been brought about by the ultra-violet light. On the analogy of the gradation in chemical properties between chlorine, bromine, and iodine, the author has endeavoured to ascertain whether a similar gradation occurred in the photoelectric effect. Taking a series of stable halogen compounds, he finds that except in the case of Cd the effect increases with the atomic weight of the halogen, and in every case the effect produced by Br is intermediate between those of Cl and I. Regarding the variation of the emission with time, the author finds some cases where the effect increases with exposure, and opines that here reduction must have been produced by the ultra-violet light. If such an interpretation be correct the electrometer should prove of value to chemists for studying photochemical phenomena too delicate for ordinary means of investigation.

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H. H. Ho.

317. Photoelectric Properties and Contact Resistances of Thin Kathode Films. **II. O. Stuhlmann, Jr., and K. T. Compton.** (Phys. Rev. 2. Ser. 2. pp. 827-828, Oct., 1918.)—A continuation and summary of results described in a previous paper [Abstract No. 127 (1914)]. The following additional point is noted. The saturation currents from thin sputtered films appear to be larger than those obtained from ordinary Pt. They increase approximately logarithmically with the thickness of the film and are therefore proportional to the amount of light absorbed by the film.
A. E. G.

318. The Photoelectric Effect. **L. Page.** (Amer. Journ. Sci. 86. pp. 501-508, Nov., 1918.)—Compton has shown that in measuring photoelectric currents corresponding to different accelerating potentials the contact p.d. between the metal exposed to the ultra-violet and the receiving electrode must be taken into account [Abstract No. 1415 (1912)]. As this contact p.d. may amount to 1 volt or more, and as the potentials used to retard or accelerate the emission of the electrons are generally not more than 2 volts, it is obvious that serious misapprehensions may result from the failure to make correction for it. Richardson and Compton have shown that when this contact p.d. is taken into account the saturation point is independent of the wave-length of the ultra-violet light and of the nature of the metal, and always falls on the corrected axis of ordinates, *i.e.* zero volts. This leads to the conclusion that no helping field is necessary to cause the max. emission of electrons under the influence of ultra-violet light, but that any hindering field, however small, will diminish the photoelectric current. The present investigation is undertaken to verify the results obtained by Richardson and Compton, to investigate the effect of scraping in vacuum the metals which are to be exposed to the light, and to obtain, if possible, experimental evidence of the nature of the contact p.d. between metals. The special arrangement for scraping the metals is described in detail. By replacing the copper receiving electrode by one of Al it is shown that the contact p.d. should be corrected for as well when the metals which are exposed to the light have been scraped in vacuum as when they have been scraped in air. The max. energies satisfy Einstein's equation $L = h\nu - P$ provided a somewhat smaller value of h is used than that usually attributed to the radiation constant. This is equally true of scraped and unscraped metals. The shift of the saturation point (the true zero potential) in the direction of increasing electro-positiveness after scraping in vacuum indicates that the constant p.d. is due essentially to a double layer on the surface of the metal.
A. E. G.

319. The Electric Arc in Liquids. **W. Hallström.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 2. pp. 1-14, 1913.)—Describes experiments on the electric arc in liquids, made with the object of examining the effect of cooling. Owing to experimental difficulties the only liquids used were methyl and ethyl alcohols and ethylacetate, while the electrode metals were similarly restricted to Cu, Ag, Al, and Ni. In liquids, as in gases, the arc can exist in two distinct states, the transition from one to the other occurring at higher currents in the case of liquids owing to their greater cooling effect. The two states give parallel V-I curves for each type of arc, except in the case of soft Cu electrodes, when the curves meet in a well-defined point. The results obtained were found to agree fairly with the equation $V = a + b\lambda + (c + d\lambda)/I$, where a, b, c, d are constants and λ is the arc length. The difference between calculation and experiment is explained by the fact that the W-I curve, formerly assumed a straight line, was found to be slightly curved. From

experiments with Ag, Cu, Al and Ni in ethyl alcohol, it appears that the higher the conductivity of the electrode, the higher the voltage, Ni forming an exception. Experiments with Cu electrodes in each of the three liquids show that the voltage increases with the diffusivity of the liquid. J. W. T. W.

320. Line Spectrum from Uncharged Molecules. C. D. Child. (Phil. Mag. 26. pp. 906-911, Nov., 1918.)—Experiments are described in which under suitable conditions it is found that the luminosity of the mercury-vapour passing from a mercury lamp to a condensing chamber can be removed by the application of an electric field, which, however, does not concentrate the luminosity at any point. From these observations and the fact that the luminosity gives a line spectrum identical with that given by the arc itself, the author concludes that the light can neither be due to chemical action nor to ionisation of the vapour either in the arc or after it has left the arc; the facts, however, are readily explained on the assumption that the light is caused by the recombination of the ions to form uncharged molecules. The author has previously shown that the luminosity is not due to the absorption of radiation from the arc. F. J. H.

321. Columnar Ionisation Theory. G. Jaffé. (Ann. d. Physik, 42. 2. pp. 808-844, Sept. 28, 1918.)—The author discusses the columnar ionisation hypothesis [see Moulin, Abstract No. 1485 (1909); Wheelock, Abstract No. 115 (1911)] and derives a formula for the distribution of the ionisation density in a column and its variation with time, account being taken of the diffusion and recombination. The theoretical values for the diffusion losses in different gases and liquids are in agreement with experimental results. Formulæ are also deduced which represent the processes occurring in a column in an electric field of any direction as regards the column. The theoretical saturation curves are in accord with experiment for (1) gases under normal pressure ionised by α -rays, (2) gases under high pressures ionised by β -rays, (8) hexane, ionised by either α - or β -rays. The ways in which, according to the formulæ, the saturation curves depend on the direction of the electric field, on the pressure, on the linear ionisation density, and on the temperature are in quantitative agreement with the experimental observations. The diameter of a column produced by α -rays, i.e. the mean distance of the ions from the axis of the column in the initial state, in different media is proportional to the range of the α -rays. It is hence possible to calculate beforehand the saturation curves for any gaseous or liquid medium. T. H. P.

322. The Brush Discharge. A. Vosmaer. (Metallurgical and Chem. Engin. 11. pp. 628-629, Nov., 1918.)—An article dealing with the application of the brush discharge to ozone production on a large scale. The conditions necessary for the production of the three types of discharge at the atmospheric pressure, viz. the glow, the brush, and the arc, are first discussed, and the arrangement found by the author, as the result of a large number of experiments, to be the most suitable for the efficient production of ozone is described. By shunting the ozonator with a condenser and introducing a suitable inductance in the secondary of the transformer used to produce the discharge, a safety device is effected, an arc discharge being impossible with this arrangement. The author has, however, come to the conclusion that the original form of apparatus, the glass-dielectric ozonator, is the best as arcing is impossible and the conditions have not to be adjusted so precisely as in

those which have no solid dielectric. The frequent failures which have been experienced with this form through the fracture of the glass are nearly always caused by overloading. F. J. H.

323. *Electric Dispersion in Benzol, Toluol, and Petroleum.* A. R. Colley. (Phys. Zeitschr. 14. pp. 898-908, Sept. 15, 1918).—Maintains that Linnitschenko's method [Abstract No. 1717 (1918)] of wire-waves is at least 10 times less sensitive than that of Colley and Obolensky, and that Linnitschenko's failure to obtain the alleged electric dispersion in benzol, toluol, and petroleum is thus accounted for. E. E. F.

324. *Measurements in the Electromagnetic Spectrum of Water with Slightly Damped Vibrations of 65-20 cm. Wave-length produced by Shock.* H. Rukop. (Ann. d. Physik, 42. 8. pp. 489-532, Oct. 16, 1918).—A number of concordant measurements of the refractive index of water for very long electromagnetic vibrations give the value, 9 (8·820-9·058) at 17°. For the production of short electric vibrations, oscillators of the Settnik type [see Abstract No. 782 (1911)] were employed, the arrangement being such that the vibrations extended over about two octaves and that any wave-length within these limits could be easily obtained. The vibrations obtained were almost monochromatic and but slightly damped, the decrement being restricted to 0·04 for $\lambda = 20$ cm. and to 0·0197 for $\lambda = 40$ cm., including the resonator. With the aid of these oscillators, the refractive index of water may be determined to within 0·15 per cent. Within the region examined, water exhibits several distinct anomalous dispersion bands, but the complicated dispersion phenomena apparently found by Colley [Abstract No. 121 (1909)] could not be confirmed. T. H. P.

325. *Electric Oscillations in Thin Rings.* C. W. Oseen. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. 12. pp. 1-80, 1918. Phys. Zeitschr. 14. pp. 1222-1226, Dec. 1, 1918).—Highly analytical treatment, including integro-differential equations, and dealing partly with resonating circuits. E. H. B.

326. *Diffraction of Electric Waves at a Straight Edge.* C. W. Oseen. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 28. pp. 1-14, 1918).—A mathematical treatment on the basis of Maxwell's equations from which the author concludes that it is extremely unlikely that the continuous spectrum can play any essential part in the question of the radiation of electric waves round the earth. E. H. B.

327. *Coupled Oscillation Systems with Single Frequency.* A. Kalähne. (Ann. d. Physik, 42. 5. pp. 1001-1080, Dec. 2, 1918).—A purely theoretical paper. The biquadratic equation, which has to be solved in the case of two coupled oscillating systems with two degrees of freedom is considered in regard to those cases in which several roots are the same or at least their real or imaginary parts are equal, i.e. when there is one resultant frequency for both systems or, the frequencies of the resulting oscillations being different, the damping is the same. The object of the paper is to show under what circumstances the one or other of the above three cases happens and what consequences follow. The paper falls into three parts: (1) a purely mathematical investigation into the three cases; (2) a physical part regarding the various kinds of coupling and the resulting relations between frequency, damping, and coupling; (3) a special physical part in which the theory is applied to certain special oscillation systems. T. P. B.

328. *Oscillations of Coupled Systems.* S. Janss. (Phys. Zeitschr. 14. pp. 896-898, Sept. 15, 1918.)—The "beats" of closely-coupled oscillatory circuits can be shown by means of a vacuum-tube detector (Diesselhorst). But the author has also succeeded in demonstrating them by means of Feddersen's rotating mirror. The photographs obtained, some of which are reproduced, show that the primary amplitude is a minimum when the secondary amplitude is a maximum, and *vice versa*. The frequency of beats increases with the closeness of the coupling. The action of a quenched spark is also illustrated by the same method. E. E. F.

329. *Effect of Ionisation of Air on Electrical Oscillations and its Bearing on Long-distance Wireless Telegraphy.* E. H. Barton and W. B. Kilby. (Phil. Mag. 26. pp. 567-578, Oct., 1918.)—Eccles attributes the bending of wireless waves round the earth to a higher velocity of propagation in the upper regions of the atmosphere owing to ionisation [see Abstract No. 109 (1918)]. Following out this idea the authors investigate the effect of ionisation of the air between the plates of a condenser in an oscillation circuit on the frequency of oscillation of the circuit. The frequencies employed are of the order of 2×10^6 per sec. Theory relating to the frequency of oscillation of a leaky condenser circuit is given. It shows that the growth from zero of a leak in a condenser at first increases the frequency, but with increasing leak the change in the frequency rises to a maximum, falls off to zero, and then changes sign. The theory is investigated by means of a Fleming cymometer, which is made specially sensitive. Across the terminals of the cymometer condenser a zinc-plate condenser is connected. The air between the plates of this condenser is ionised to varying degrees by Röntgen rays or radium rays. The cymometer is excited by an ordinary spark oscillation circuit. By means of a special electrometer resonance curves are obtained, as the ionisation of the air in the plate condenser is varied. Curves connecting change of frequency with degree of ionisation confirm the theory. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

330. *P.D. Necessary for an Electric Current through Mercury at 4.19° K.* H. Kamerlingh Onnes. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1406-1480, July 15, and 16. pp. 118-124, Sept. 8, 1918. Electrician, 71. pp. 855-857, Aug. 29, 1918. Abstract.)—The author's investigations have been continued, the earlier result, that the almost sudden resistance change begins at 4.21° K. and ends within a fall of 0.02 deg., being confirmed and extended [Abstracts Nos. 1220 and 1042 (1911)]. Using the resistance employed in the earlier experiments, the highest limit of the value which the residual resistance can have in the case of the lowest temperature, in this case 8.65° K., was found to be 10^{-6} of the resistance at 0° C. (calculated for solid mercury). Next, two new mercury resistances were constructed in which it was aimed at reducing in every way the possibility of disturbances arising from the conduction of heat from a part of the apparatus having a higher temperature. The new resistances were of 50 ohms and of 180 ohms, and the threads were contained in tubes of 0.004 mm.² and 0.0018 mm.² cross-section respectively. With these the highest limit for the resistance was found to be reduced, at 8.6° K., to $< 4 \times 10^{-10}$ of the value at 0°. This heat-isolation principle was still further extended in the case of some additional threads which were built with auxiliary leads consisting of mercury "sentinel" threads

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of larger cross-section in order to provide a longer path before the heat could affect the "resistance" threads. With these resistances the limit was brought down, at 2.45°K. , still further to $< 2 \times 10^{-10}$ of that at 0°C. , the p.d. at the extremities of the thread being only 0.56 microvolt when the current density in the mercury was 1024 amps. per square millimetre. Mention is also made of the discovery that at these temperatures the resistance disappears also in the case of mercury amalgam and of pure tin. L. H. W.

331. *Anomalous Conduction in a Solid Dielectric.* W. F. G. Swann. (Phil. Mag. 26. pp. 878-898, Oct., 1918.)—An apparatus (consisting of a charged plate embedded in paraffin wax occupying the space between two other parallel plates) was used to detect the deviation, if any, of the conduction of the wax from Ohm's law.

The theory and possible errors are discussed, and it is shown that the only likely way of accounting for the results obtained is by the assumption of a departure from Ohm's law such as corresponds to an increase of the conductivity with the field. The reasons for discarding any explanation of the phenomenon as due to soakage are discussed, and the possibility of its explanation as the result of an increase in the ionisation, due to the field, is examined and found untenable. A method of accounting for the phenomenon is put forward framed on the lines of a modification of J. J. Thomson's theory of metallic conduction. E. H. B.

332. *Thermal and Electrical Conductivities of the Alkali Metals.* J. W. Hornbeck. (Phys. Rev. 2. Ser. 2. pp. 217-240, Sept., 1918.)—The thermal and electrical conductivities of sodium and potassium and of an equiatomic Na-K alloy have been measured by Jaeger and Diesselhorst's modification of the original Kohlrausch method, a steady electric current being passed through a cylindrical rod of the metal and the temperature and p.d. measured at three equidistant points along the axis of the rod, while the temperatures of the ends of the rod and of the surrounding jacket are kept constant. The specific resistance of sodium at 21.7° is found to be 5072×10^{-9} ohm-cm., its temperature-coefficient being 0.00618 over the range $6-88^{\circ}$; the value for potassium at 20.7° is 7010×10^{-9} ohm-cm. and the temperature-coefficient 0.00552 for $5-58^{\circ}$. Considering the wide difference in the methods of measurement, these results agree as closely as could be expected with Northrup's numbers [Abstract No. 888 (1912)]. The thermal conductivity for sodium diminishes from 0.821 at 5.7° to 0.288 at 88.1° and that for potassium from 0.282 at 5.0° to 0.216 at 57.4° .

The values of the ratio of the electrical to the thermal conductivity, $\sigma : \lambda$, are extremely high, but the alkali metals behave in no exceptional way as regards the absolute values of these conductivities at ordinary temperatures.

As a check on the method employed, the ratio $\sigma : \lambda$ was determined for lead at room temperature, the value obtained agreeing with that found by Jaeger and Diesselhorst [Abstract No. 187 (1900)].

A modification of the electron theory of metallic conduction is suggested which accounts for the variation of the specific heat with the temperature and also explains the curves obtained by Lees [see Abstract No. 1877 (1908)] for the ratio $\lambda : \sigma T$ for the pure metals at low temperatures [see Wien, Abstract No. 658 (1918)]. T. H. P.

333. *The Silver Voltameter.* H. v. Steinwehr. (Zeitschr. Instrumentenk. 88. pp. 821-880, Nov., and pp. 858-867, Dec., 1918.)—Communication from VOL. XVII.—A.—1914.

the Physikal.-Techn. Reichsanstalt.)—The first part of this paper reviews the possible sources of error of the silver voltameter [see Abstracts Nos. 868; 1688 (1908); 187, 287 (1909); 486, 1008 (1910); 501, 508 (1918)]. The effect on the deposit of the anode liquid is considered to be negligible, and the temperature coefficient is negligibly small. The influence of reducing substances, of silk, and of oxygen, on the mass of the deposit cannot be regarded as decided, and questions connected with the volume of the electrolyte, and the solution enclosed (if any) in the deposit are not yet settled. However, in practice, the total effect must be very small. The types of voltameters most studied in recent years are those of Richards, Kohlrausch, and a new form introduced by Smith. The author thinks it better to keep the solution free from contact with possibly injurious substances, and therefore prefers the last two forms. The most recent experiments made at the Reichsanstalt give 1.01829 int. volts as the e.m.f. of the Weston normal cell at 20° C., a value which is practically identical with that adopted (1.01880 int. volts) by the International Scientific Committee on Electrical Units and Standards. Tables show the variation in the e.m.f. of the cells used to be of the order of only 1 part in 100,000 and there is evidence that these cells agree with others in various countries. The number of international coulombs required for the deposition of 1 gm.-equivalent of a substance is given as 96,494.

F. E. S.

334. The Mutual Forces between Electromagnetic Systems. J. Bethenod. (*Lumière Électr.* 24, pp. 71–78, Oct. 18, 1918.)—If F be the force of attraction between two circuits the induction coefficients of which are L_1, L_2 , if they are carrying currents i_1 and i_2 , and x being the distance between their centres, then it is proved that

$$F = (i_1^2/2)(\partial L_1/\partial x) + i_1 i_2 (\partial M/\partial x) + (i_2^2/2)(\partial L_2/\partial x).$$

It is shown how this formula enables us to explain the working of several electromagnetic devices.

A. R.

335. Effect of Radiation on Telephone Receiver. I. Malmer. (*Ann. d. Physik*, 42, 8, pp. 685–688, Oct. 16, 1918.)—The paper has reference to Grotrian's experiments on e.m.f. induced in the coil of a telephone receiver when radiation falls on the diaphragm [Abstracts Nos. 676 and 1198 (1918)]. The author uses a string galvanometer which enables him to follow, by photographic record, the variation of the induced current throughout the period the radiation falls on the diaphragm. The current curves are always of the same character and indicate that the effect is due to unequal expansion of the diaphragm by heat and not to a change of permeability. The bending of the diaphragm is observed by an optical arrangement.

A microphone also reacts under radiation.

T. P. B.

336. A Dust Electrical Machine. W. A. D. Rudge. (*Cambridge Phil. Soc., Proc.* 17, pp. 249–250, Sept. 8, 1918.)—The author has previously noticed that dust clouds are capable of carrying large quantities of electricity into the atmosphere. The present paper describes an instrument designed to acquire a charge from artificially raised dust clouds. Sparks up to 5 cm. in length may be obtained in a suitably dry atmosphere. J. S. DI.

337. A Reading Optophone. E. E. Fournier d'Albe. (*Electrician*, 72, pp. 102–108, Oct. 24, 1918.)—The arrangement of selenium bridges in VOL. XVII.—A.—1914.

the "Optophone" [see Abstract No. 964 (1918)] is modified so as to give an indication of the shapes of letters through the medium of a telephone. A selenium bridge of high sensitiveness and resistance is put in series with a telephone and a battery giving 200 to 1000 volts. The selenium is illuminated by a line of light furnished by an Osram "striplite," which is concentrated on the selenium by a cylindrical water lens. A revolving brass disc with concentric circles of holes, somewhat resembling a siren disc, breaks up the line into luminous dots of various frequencies. In the instrument constructed, these frequencies are in the ratio of the notes of the major diatonic scale. When nothing is interposed between the disc and the selenium, the telephone gives out a chaos of sounds corresponding to all the notes sounded simultaneously. But when a transparency, say of a printed letter, is interposed, it breaks up the sound into distinct notes, which vary as the letter is moved past the luminous line. The various letters can then be recognised by their characteristic sounds. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

338. *Change in Electrical Resistance due to the Orientation of Oblate Spheroids within the Conductor.* S. R. Williams. (Phys. Rev. 2. Ser. 2. pp. 241-248, Sept., 1918.)—Experiments were carried out to obtain support for the assumption that a ferromagnetic substance is made up of oblate spheroids which receive a definite orientation when in a magnetic field. There can be little question that a number of factors are combined to give the effect described as change of resistance due to a magnetic field. In one metal one factor may predominate, and in another metal some other factor may hold sway. [See also Abstract No. 258 (1918).] G. E. A.

339. *Twist in Steel and Nickel Rods due to a Longitudinal Magnetic Field.* S. R. Williams. (Amer. Journ. Sci. 86. pp. 555-562, Nov., 1918. Paper read before the Ohio Acad. of Science, Nov., 1912.)—Besides the magnetostrictive effect, Wiedemann found that if an iron rod was first twisted mechanically and then subjected to a longitudinal magnetic field, it would also twist mechanically due to the imposed field. The paper deals with the investigation of twelve steel rods and two nickel rods. These were suspended by the upper end in a vertical solenoid, and a concave mirror attached to the lower end threw the image of a glowing filament on a slit behind which a photographic film moved. There was very little twist in the steel rods. In the nickel rods the twist rises to a maximum in a field of about 20 c.g.s., diminishes to a minimum when the field is about 85, and thereafter increases with the field. The rods not previously demagnetised show a much larger twist than those from which at least a part of the permanent magnetisation has been removed. A close inspection of the rods indicated that in the process of drawing they had been given a permanent torsional set. The conditions for a twist due to a longitudinal magnetic field seem to be (1) the presence of a permanent torsional set, or (2) the elementary magnets may be swung into spiral formations by magnetic processes. [See preceding Abstract.] G. E. A.

340. *Effect of Transverse Field on Longitudinal Magnetisation.* A. Amerio. (Atti dell' Assoc. Elett. Ital. 17. pp. 1178-1181, Dec. 15, 1918.)—Continuing the investigation of the simultaneous magnetisations at right angles to each other, of G. Vallauri and others [see Abstract No. 1802 (1909)], the author magnetises an iron wire in some cases, and an iron tube in others, VOL. XVII.—A.—1914.

by means of an external solenoid, the cycle of magnetisation being observed by means of a Braun tube. The transverse field is produced by a current in the iron wire, or in the case of the tube by a current in a copper wire situated in the axis of the tube. In all cases there is a diminution of hysteresis along with a lowering of the longitudinal susceptibility, and with sufficiently great transverse field the hysteresis vanishes. The effect is due to the transverse field and not to the direct action of the current, for in the case of the wire the effect is identical with that for the tube whenever the transverse fields are equal in the two cases. S. G. S.

341. *The Magneton and Planck's Constant.* S. B. McLaren. (Phil. Mag. 26, p. 800, Oct., 1918.)—Bohr's view of Planck's constant as an angular momentum, which was very prominent in the recent British Association discussion on Radiation, makes it of interest to note that the magneton provides a natural unit of this nature. The author finds that a magneton of any cross-section or aperture has an angular momentum about its axis of $(8\pi^2 V)^{-1} N_e N_\mu$, where V is the velocity of light, N_e is the number of tubes of electric induction terminating on the surface, and N_μ is the number of tubes of magnetic induction passing through the aperture. G. W. DE T.

342. *Kerr-effect in Ferromagnetic Compounds.* P. Martin. (Konink. Akad. Wetensch. Amsterdam, Proc. 16, pp. 818-881, Oct. 24, 1918.)—In continuation of a previous paper [see Abstract No. 280 (1918)] some new dispersion curves are given, and in some cases the relation between the Kerr-effect and the temperature is also given. (1) In MnAs the rotation in the yellow amounted to $1.5'$ and appeared to vanish in the orange: temperature of loss of magnetism (θ_0) 45° . (2) In MnSb the rotation is constant below 60° and decreases from 80° to a minimum about 265° . (3) Iron carbide showed a powerful rotation (between $-18'$ and $-21'$), with a maximum in the yellow and a minimum in the orange-red: $\theta_0 = 235^\circ$. (4) Ferro-silicon has a powerful negative rotation increasing continuously from the violet to the red. The rotation apparently vanishes about 460° . (5) Ferro-cobalt gave the strongest rotation yet observed, the curve rising to a maximum in the red of $-84'$. (6) Ferro-nickel has a maximum in the yellow and a minimum in the red. Curves are also given for a number of bodies belonging to the metaferriite series. G. E. A.

343. *Spontaneous Magnetisation and the Assumption of a Zero-point Energy.* W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 16, pp. 454-467, Nov. 27, 1918. Communication No. 82a from Phys. Lab., Lieden.)—The quantum theory is introduced into Weiss's theory for the ferromagnetic state, and expressions are obtained for the spontaneous magnetisation. From these, curves are drawn for magnetite and nickel in which the ratio, Spontaneous magnetisation to absolute saturation magnetisation is plotted against the ratio, Absolute temperature to absolute temp. of the Curie point. The agreement between observation and calculation is considered satisfactory in the case of magnetite. This is taken to indicate that the application of the quantum theory corresponds in its principal features to reality, particularly as regards the assumption of a zero-point energy. G. E. A.

344. *Susceptibility in the Excited Ferromagnetic State.* W. H. Keesom. Konink. Akad. Wetensch. Amsterdam, Proc. 16, pp. 468-476, Nov. 27, 1918. VOL. XVII.—A.—1914.

Communication No. 82b from Phys. Lab., Leiden.)—The assumption of a zero-point energy for the molecular rotations involves the possibility of the existence of ferromagnetic substances without a Curie point. If, with constant molecular magnetic moment and constant zero-point energy, the molecular field increases from zero, five cases may be distinguished of which two have no Curie point. The question of the increase of molecular magnetic moment with temperature is also discussed.
G. E. A.

345. Magnetism of Crystals and Energy at Absolute Zero. G. Foex. (Comptes Rendus, 157, pp. 1145–1148, Dec. 8, 1918.)—It has been established that paramagnetic solids do not follow Curie's law at very low temperatures [see Abstracts Nos. 400 (1912) and 698 (1918)], and Oosterhuis attributes the divergence to the existence of kinetic energy of rotation of the molecules at absolute zero. The author considers that it is unnecessary to give up the classic kinetic theory. Actual experimental results do not enable us to conclude definitely for or against the kinetic theory, but arguments are drawn from Weiss's theory to show that the existence of a molecular field, when taken in conjunction with the properties of crystals, is sufficient to account for the divergence from Curie's law at low temperatures.
G. E. A.

346. Curie's Law and Energy at Absolute Zero. E. Oosterhuis. (Phys. Zeitschr. 14, pp. 862–867, Sept. 15, 1918.)—The existence of a zero-point energy has been suggested by several recent investigations. Einstein and Stern have explained the variation of the specific heat of hydrogen on the assumption of a zero-point energy, and the same assumption has been found necessary to account for rectilinear translation in gases, and Keesom has shown that the quanta theory is aided by such an assumption in the explanation of the motion of force electrons in metals, several difficulties in connection with the equipartition of energy being thus eliminated. That there is a zero-point energy of rotation is supported by the magnetic susceptibility of paramagnetic substances. For most of the deviations from Curie's law found at low temperatures, of which there are three types, may be reduced to a single type, and explained quantitatively on this assumption.
E. E. F.

347. The Magnetisability of Titanium Compounds. E. Wedekind and P. Hausknecht. (Ber. Deut. Chem. Gesell. 46, pp. 8768–8768, 1918.)—Measurements with the following compounds of titanium: titanium dioxide and disulphide, and sulphide (Ti_2S_3), titanous sulphide, TiS , the oxide, Ti_2O_3 , showed that the magnetic susceptibility increases as the valency of the Ti diminishes [compare Wedekind and Horst, Abstract No. 751 (1912)]. Titanium peroxide, $TiO_2 \cdot 8H_2O$, is feebly diamagnetic. Comparison with the compounds of Mn, Cr, and V shows that the susceptibility decreases with decreasing atomic weight, reaching its lowest value in the compounds of Ti. The oxide, Ti_2O_3 , was obtained by heating the dioxide at 1250° for 18 hours in a current of oxygen and nitrogen-free hydrogen.
T. S. P.

348. Magneton- and Stere-Numbers of Magnetic Kathions. A. Heydweiller. (Deutsch. Phys. Gesell., Verh. 15. 17, pp. 821–825, Sept. 15, 1918.)—The atomic volume of an atom or ion may be calculated from refractive moduli and in simple cases is usually a multiple of the "elementary-stere," 0.292 c.cm. per gm.-ion, the multiple being called the "Stere-number," e.g. 2 for helium. The following table shows the stere-numbers ρ and the

magneton-numbers n for a series of ions whose magnetic properties have been measured :—

	Mn''	Fe''	Co''	Ni''	Cu''	Cr''	Fe'''
p	19	18	18	16	15	26	28
n	29	27	24	16	9	18	28

The stere-numbers are practically constant for the five divalent and again for the two trivalent ions, but the latter are about 50% greater than the former, *i.e.* in proportion to the valency, in spite of the fact that the atomic volumes do not differ widely. The magneton-numbers are of the same order of magnitude as the stere-numbers. It was anticipated that they would always be smaller, the number of electrons producing an external magnetic field being less than the total number, but this is not borne out by the actual figures.

T. M. L.

349. Phenomena of Sun-spots and Terrestrial Magnetism. C. Chree. (Roy. Soc., Phil. Trans. 218. pp. 245-277, Aug. 8, 1918.)—In a previous paper [Abstract No. 1046 (1912)] an investigation was made of the existence of any relation between the magnetic character of individual days and that of days separated from these by a given interval. The mean character figures show clearly the existence of a period somewhat in excess of 27 days, and a long analysis of the data available gives this value as probably 27.16 days. Examination of the minor pulses shows evidence of their occurrence at 54- and 81-day intervals after or before main disturbance, and the curves of magnetic character plotted in this manner are remarkably symmetrical. The results are then discussed in relation to the areas of sun-spots during the period 1890-1910. The curves of sun-spot area and magnetic character have their crests practically in synchronism, but the form of the two pulses is widely different. This tendency of a 27-day period in magnetic disturbance is apparently as clearly marked in sequences of quiet days as in disturbed days, and in years of many or few sun-spots. It was particularly prominent in 1911, when sun-spots were few. Thus, while the two phenomena appear to be related, they may be in widely different phases at the same epoch.

C. P. B.

350. Lunar and Solar Diurnal Variations of Terrestrial Magnetism. S. Chapman. (Roy. Soc., Phil. Trans. 218. pp. 279-321, Aug. 22, 1918.)—Referring to Schuster's theory [Abstract No. 1158 (1908)], in which the diurnal variations of terrestrial magnetism are attributed to the action of e.m.f.'s produced in masses of conducting air in the upper atmosphere, by their motion across the permanent magnetic field of the earth, it is conceded as probable that the relative magnitudes of the diurnal and semi-diurnal terms in the magnetic potential arise in part from the variation of conductivity of the atmosphere with the solar hour angle, but the great excess of the summer variation over the winter variation is unexplained. In the present paper the principal facts concerning the lunar magnetic variation are summarised, and some new facts presented which have been deduced from harmonic analysis for the lunar variation at separate phases. For the discussion of these results Schuster's calculation of the effect of an atmospheric oscillation has been extended, the work being rendered simpler and more direct by adopting resistivity, instead of conductivity, as the variable. A fuller discussion of the seasonal variations will be given when the new determination of the potential of the field responsible for the solar diurnal variations, now in progress at Greenwich Observatory, is completed.

C. P. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

351. *The Oxidation of Nitrogen and Oxygen.* W. W. Strong. (Amer. Chem. Journ. 50. pp. 204-212, Oct., 1918.)—Referring to the researches of Strutt on afterglows and active nitrogen and of J. J. Thomson on positive-ray analysis, the author points out that, according to the latter, many ways of forming ozone and nitric oxide from different particles would be possible. Of these $\bar{O}_2 + \bar{O} = O_3$ and $\bar{O}_2 + \bar{N}_2 = 2NO$ appear most probable to him. He then describes experiments with the "corona" discharge passing between a cylinder and its axial wire (or wires), either of which may be earthed; this corona discharge differs from the brush discharge. Drawing off the gases, when the discharge passes through air into caustic soda, he finds that the energy consumed in the formation of nitric oxide is about the same as in the several processes applied for the electric oxidation of nitrogen. H. B.

352. *New Researches on Liquid Crystals.* O. Lehmann. (Akad. Wiss. Heidelberg, Ber. 1918. Chem. News, 108. pp. 191-198, Oct. 17; 201-204, Oct. 24, and pp. 211-214, Oct. 31, 1918. Abstract.)—The author's experiments on ammonium oleate, as well as his theories of liquid crystals, having been criticised by Młodziejowski, new series of experiments have been carried out in confirmation of the earlier observations. Detailed directions are given for preparing the hydrated liquid-crystalline modification of neutral ammonium oleate, and it is shown that the separate crystals possess the property of welding together when they come into contact. The "liquid crystals behave as if they consisted of mobile but approximately rigid leaflet-shaped molecules, which exercise turning moments (couples of forces) upon one another, comparable with those of astatic systems of magnets formed of revolving electrons (in paths which form knots)." T. M. L.

353. *Influence of Temperature and Pressure on the Volatility of Zinc and Cadmium.* T. K. Nair and T. Turner. (Chem. Soc., Journ. 108. pp. 1584-1548, Aug., 1918.)—The authors have continued the work on the behaviour of metals when heated *in vacuo* [see Abstracts Nos. 1458 and 1459 (1912)]. Experiments on a practical scale with 150-kg. charges showed that imperfections in the vacuum considerably diminished the rate of volatilisation of zinc, and accordingly a study was made of the rate of volatilisation of zinc and cadmium at various temperatures *in vacuo* and at various temperatures and pressures in air, hydrogen, and CO. The results show that hydrogen and CO have nearly as marked an effect as air in diminishing the rate of volatilisation. At each pressure there is a certain critical temperature, above which the rate of volatilisation is directly proportional to the temperature. This critical temperature is raised by pressure, the first increases having the most marked effect. The pressure-temperature curve for equal rates of volatilisation is steep from 0-50 mm., when there is a sudden change in direction, the curve becoming a straight line above 80 mm. Down to 50 mm., each mm. removed has a small but equal effect in lowering the rate, which is only about $\frac{1}{10}$ that of removing the last mm. F. C. A. H. L.

354. *The Allotropic Transformations of Iron.* A. Sauveur. (Iron and Steel Inst., Journ. 88. pp. 171-181; Discussion and Correspondence, VOL. XVII.—A.—1914.

pp. 182-190, 1918. Engineering, 96. pp. 853-854, Sept 12, 1918.)—According to Benedicks (Ibid. 86. p. 242, 1912), when absolutely pure iron cools down to A_1 , the γ molecules are converted into α molecules, and there should therefore be no A_2 point in absolutely pure iron. In the presence of small amounts of carbon or other impurities, the change is not complete at A_3 , but extends over a range ending at A_2 . If these views are correct, both A_2 and A_3 should be absent in pure iron; A_2 should reappear in the presence of impurities, but not so A_3 , since this would imply the impossible conception of appearance of metastable γ iron on heating. The intensity of A_2 should increase, and of A_3 decrease, with the amount of impurities present. Now A_3 is found in nearly all the published heating curves of nearly pure iron—a point which has been confirmed in the author's laboratory by autographic curves of an iron of at least 99.7 % purity taken with a le Chatelier-Saladin galvanometer. All the curves show A_3 with apparently undiminishing intensity after 12 repeated heatings and coolings. A 0.4 % carbon steel has two critical points at A_3 and A_1 , and on Benedicks' reasoning the A_1 point should be the retarded end of A_3 , and should not occur on heating. Again a 0.15 to 0.20 % carbon steel should by the same argument show two critical points, A_3 and A_1 , the latter being the retarded end of the former, and no meaning can be attached to A_2 , nor should A_3 appear on heating. To sum up: the points which have not yet been reconciled with Benedicks' theory are:—(1) It has not been shown that A_2 is absent in absolutely pure iron; (2) A_3 is always present in autographic heating curves of pure iron; (3) the point A_3 or A_3 is generally detected in steels containing less than 0.6 % carbon; and (4) iron loses the bulk of its magnetism at 780° to 800° C., and not at A_3 .

F. C. A. H. L.

355. *Crystallising Properties of Electro-deposited Iron.* J. E. Stead and H. C. H. Carpenter. (Iron and Steel Inst., Journ. 88. pp. 119-145; Discussion and Correspondence, pp. 146-170, 1918.)—Stead showed in 1898 that the fine grains of practically carbonless irons and steels are slowly increased in size by heating at 500° C. and more rapidly increased in size by heating between 600° and 750° C. Iron made coarsely granular at 700° C. is not affected by subsequent heating until the temperature exceeds 900° C., when the granules again become small. Subsequent work showed that the largest crystals are produced at 700° to 740° C., and that the refining is definitely connected with the A_3 change. The authors carried out a number of preliminary experiments on electro-deposited iron of 99.967 % purity, available in the form of finely crystalline strips, 0.25 mm. in thickness and resembling pure copper in malleability. On heating to 920° to 970° C. it formed very large crystals which could only be refined by cold work followed by annealing at 750° to 800° C. Thus the conditions which coarsen the crystals of electrolytic iron refine those of mild steel and wrought iron, and the conditions which coarsen the crystals of the latter are without effect on those of the former. This astonishing difference caused the authors to undertake a study of the conditions under which the structures of strips of electrolytic iron, mild steel, and decarbonised wrought iron are coarsened and refined. Electrolytic iron is found to develop enormous crystals after heating to above A_3 and cooling below A_3 . Although two types of crystals "equi-axed" and "columnar" are produced (frequently on the same specimen), they are not constitutionally different and most likely both are α iron. Prolonged heating above A_3 followed by slow cooling does not produce coarse crystals, probably because of the gradual destruction of the α nuclei.

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Further, the crystallisation effect appears to be a function of the thickness of the sheet, and is not obtained when the thickness exceeds a certain critical figure, the most striking effect being obtained at a thickness of about 0.01 in. Once formed, the coarse crystals can only be destroyed by cold work or by quenching from above 950° C. The experiments on wrought iron and mild steel which have been rendered coarsely crystalline by annealing at 700° to 800° C. show that they are refined by heating to the temperature (920° C.) at which electrolytic iron is coarsened. The results give no support to the view that there is any crystallographic difference between β and α iron, and are best explained on the assumption that at A78 the iron changes direct from the γ to the α condition.

F. C. A. H. L.

356. Transformations of Iron and Steel at High Temperatures. K. Honda and H. Takagi. (Rev. de Métallurgie 10. pp. 1826-1886, Dec., 1918.)—Whilst a transformation in a body is accompanied by a change in one or more of its properties, the whole of the properties are not necessarily affected, so that in studying transformations it becomes necessary to make simultaneous observations of the variations in several properties. This the authors have done by noting the time, temperature of, and magnetic properties of Kahlbaum's pure iron, samples of steel containing 0.14 to 1.50 % carbon, and a tungsten steel containing 5 % W and 0.6 % carbon, during heating and cooling. The results show that in pure iron the $\beta \rightarrow \alpha$ change takes place in a very small interval of temperature, the change in the magnetic curve being very abrupt at 765° C. The interval corresponding to the transformation $\beta \rightarrow \alpha$ or $\gamma \rightarrow \alpha$, increases with increase of carbon. In steels there is not much heat liberated in the $\beta \rightarrow \alpha$ or $\gamma \rightarrow \alpha$ changes, but the pearlite separation is accompanied by a large evolution of heat and an increase in the permeability. The temperature of the pearlite formation is 80-40° higher on heating than on cooling. Recalescence is to be attributed to the deposition of iron from the solid solution and not to the $\beta \rightarrow \alpha$ or $\gamma \rightarrow \alpha$ polymorphic transformations.

F. C. A. H. L.

357. So-called "Crystallisation Through Fatigue." F. Rogers. (Iron and Steel Inst., Journ. 88. pp. 892-896 ; Correspondence, pp. 897-898, 1918. Mech. Eng. 82. pp. 218-214, Sept. 5, 1918. Engineering, 96. p. 525, Oct. 17, 1918.)—The idea that crystallisation is caused by fatigue has been prevalent for many decades, but there has never been any direct experimental evidence in support of this view. Experience has shown that material which breaks in service with a crystalline fracture would have given the same type of break had it been broken when new. Neither does fatigue generate crystalline fracture in a material initially breaking with a fibrous fracture. Examination of a wrought-iron centre post which broke in use with a partially fibrous, partially crystalline fracture, a type generally ascribed to "crystallisation through fatigue," showed that the material had been built up of different grades of iron during piling.

F. C. A. H. L.

358. Heating and Cooling Curves of Manganese Steel. R. A. Hadfield. (Iron and Steel Inst., Journ. 88. pp. 191-196 ; Discussion and Correspondence, pp. 197-202, 1918.)—Inverse-rate heating- and cooling-curves have been taken of cast and forged specimens of two Mn steels containing 1.26% carbon, 0.82% Si, 13.88% Mn, and 1.16% carbon, 0.21% Si, 10.85% Mn respectively. No critical points were observed between 1850° and 150° C., and all the specimens remained non-magnetic during the whole of the treatment.

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Considered in the light of the remarkable changes produced in the structure and mechanical properties of Mn steels by slow cooling or quenching, the absence of critical points is remarkable. More recent work with Hopkinson indicates that Mn steels can be made magnetic by prolonged heating at 450° to 500° C. and that in this condition the steel shows a critical point commencing at about 680° C.

F. C. A. H. L.

359. *The Critical Points Ar1, Ac1*. J. E. Stead. (Iron and Steel Inst., Journ. 88. pp. 399-409; Correspondence, pp. 410-415, 1918. Engineering, 96. pp. 854-856, Sept. 12, 1918.)—The steel to be tested is forged into bars of convenient size (approx. 10 × 5 × 115 mm.) which are then filed or ground on all sides to remove the decarbonised skin. Asbestos packing is placed between two bars in such a way as to leave a central passage 1.5 mm. wide between them; the whole is bound together with thin wire and pushed into a porcelain tube in the side of a muffle heated to 1000° C. After 80 mins. there is a constant temperature gradient along the bars determined by introducing wires of silver, silver coated with common salt, of Al, and Zn into the passage and withdrawing them after 8 mins. From the length of the wire remaining unmelted the temperature at four different points on the wire becomes known and a curve can be plotted showing the temperature gradient along the bars, which are then withdrawn, quenched in cold water and one face polished and etched. A sharp line of demarcation is developed between the hardened and soft portions of the bar; the temperature which existed at this point can be obtained from the temperature gradient curve and represents the temperature of Ac1 to within 8 deg. C. Ac1 and Ar1 can be determined in the same operation by heating two bars of the same steel together and slowly drawing out one of the bars for 15 mm. after the heat is constant. The heating is then continued and the bars are treated as above. After etching the bar drawn out has the point Ar1 marked upon it, and the other bar the point Ac1.

F. C. A. H. L.

360. *Method of Measuring the Viscosity of the Vapours of Volatile Liquids, with an Application to Bromine*. A. O. Rankine. (Roy. Soc., Proc. Ser. A. 88. pp. 575-588, July 18, 1918.)—This method is based on O. E. Meyer's transpiration formula, the older methods being modified by the use of special devices for estimating the pressures at the two ends of the capillary tube and for measuring the quantity of gas passing through it. Each of two carefully calibrated U-tubes of about 2 mm. bore and 20 cm. length of limb is connected at one end with a capillary tube about 89 cm. in length and approximately 0.018 cm. radius. One of the U-tubes is filled with the liquid to be examined and the apparatus is exhausted and sealed. The tubes are enclosed in baths at constant known temperatures, chosen to evaporate and condense the liquid respectively. The connecting capillary is surrounded by a third bath at an intermediate temperature, at which the viscosity of the vapour is to be determined. The amount of the substance passing over is determined from the alteration in volume of the liquid in the U-tubes. The apparatus being symmetrical, measurements in alternate directions may be performed successively. The apparatus, both in its final form and during the process of filling, is entirely devoid of taps, absence of tap grease being regarded as necessary in order to avoid the production of impurities due to chemical action on it of the bromine, with which viscosity measurements were made at temperatures varying from 285.9° to 496.4° abs. The values found for $\eta \times 10^4$ in c.g.s. units at different absolute temperatures are: 496.4°,

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2480 ; 452.8°, 2278 ; 412.8°, 2079 ; 372.8°, 1885 ; 338.8°, 1706 ; 285.9°, 1511. These values agree well with those obtained by the author by another method [see Abstract No. 685 (1912)] and, with the exception of those for the two lowest temperatures, are in accord with the numbers calculated from Sutherland's equation.

Although various gases, without distinction of kind, obey approximately the law, $T_c/C = \text{constant}$, where T_c is the absolute critical temperature and C Sutherland's constant, still better agreement is obtained among the members of a single group of the periodic system. Further, it has been found that, for the group of inert gases the square of the viscosity at the critical temperature is proportional to the atomic weight or $\eta_c^2/A = \text{constant} = 8.98 \times 10^{-10}$, where η_c is in c.g.s. units and A is the atomic weight relative to oxygen. With Cl and Br, the values of this constant are 1.02×10^{-9} and 1.08×10^{-9} respectively, so that the law seems to possess wider application than merely to the inert gases, the constant having different values for each group in the periodic table.

The values of the viscosity are used to estimate the molecular magnitudes of Cl and Br, the diameters being 8.15 and 8.86×10^{-8} cm. and the volumes 1.80 and 1.59×10^{-22} c.cm respectively ; the density of the atom of Br hence seems to be about twice as great as that of Cl.

T. H. P.

361. New Electrical Method of Preparing Aqueous Colloidal Solutions of Metals. H. Morris-Airey and S. H. Long. (Univ. of Durham Phil. Soc., Proc. 5, pp. 68-70, 1912-1918.)—In order to combine the advantages of Bredig's and Svedberg's methods for preparing colloidal solutions of metals, the authors make use of a high-frequency alternating arc. A suitable generator is found in the Poulsen arc as used in wireless telegraphy, leads being taken from two points on the inductance of the oscillatory circuit of the arc to the terminals of a discharger circuit consisting of an arc lamp designed to allow of the arc being struck under water. The frequency could be varied from 228,700 to 865,200 per sec., the current in the discharger circuit from 0.14 to 15 amps., and the voltage from 480 to 4080 ; the length of the arc in the discharger could also be varied. In general, only a few seconds are required to produce colloidal solutions of Au, Ag, Pt, Pd, Cu, Pb, Fe, Zn, Sn, Ni, Al, Mg, Bi, Sb, or Cd ; solutions of carbon were also prepared. Certain colours have been regarded as characteristic of the colloidal solutions of many of the metals, but the above method shows that the colour is a result of the special conditions of the discharge. Where only one or two colours had been previously obtained, the authors found it possible, by suitable adjustment of the conditions, to obtain a wide range of colours with several metals. Thus, with gold, red, blue, and purple solutions are obtainable as well as a number of intermediate colours ; examination of these colloids with a Hardy tube indicates that the red and blue hydrosols carry charges of opposite signs, while the purple one appears to be a mixture of the other two. Similar results are given by other metals.

T. H. P.

362. Colour-changes in Colloidal Gold. S. H. Long. (Univ. of Durham Phil. Soc., Proc. 5, pp. 118-118, 1912-1918.)—The results of further experiments [see preceding Abstract] lead to the following conclusions : (1) Red colloidal gold in water is associated with the hydroxyl ions and moves to the kathode ; in this solution the particles are very small. This colloid may be represented by the formula, $n\text{Au}^+ + \text{H}^+ \text{OH}^- = \text{Au}_n^+ (\text{OH})^- + (\text{H})^+$; in

dependence on the conditions under which the gold was dispersed under the water, a group of particles received a positive charge, and on entering the disperse medium became associated with the negatively charged hydroxyl ions to form a gold-hydroxyl aggregate. This may be looked upon as a group of gold particles surrounded by an atmosphere of hydroxyl ions. (2) Blue colloidal gold in water is associated with the hydrogen ions and moves to the anode; in this solution the particles are larger than in the case of red colloidal gold. (3) Purple colloidal gold is simply a mixture of the red and blue colloids, the relative proportions of which determine the particular shade of purple. (4) The more stable form of gold colloid is the blue, into which the red may be changed by the action either of an electrolyte or of an electric field. Change from the red to the blue form is accompanied by change in the absorption spectrum from a large band extending throughout the orange region to a band of about one-sixth this length and with very sharply defined edges.

T. H. P.

363. Importance of Viscosity for Study of Colloidal State. W. Ostwald. (Faraday Soc., Trans. 9, pp. 84-46, July, 1918.)—Attention is directed to the great variability of viscosity in colloids: this is affected, not only by temperature and by concentration, but also by the "degree of dispersity," i.e. the size of the suspended particles, and in many cases by previous thermal or mechanical treatment. The magnitude of the viscosity varies over an extraordinary range, e.g. in a colophony-turpentine sol from 1 to 10^{30} in the range between 0 and 100 %; extreme changes may occur within a range of 1 % of concentration or 1 deg. of temperature, which is often sufficient to cause the settling of a colloid that was previously quite fluid. No better method exists of studying the changes that precede the setting of a colloidal solution than the measurement of viscosity-changes. The viscosity also reveals on an enormously magnified scale the small effects that are produced, e.g. by acids and alkalis on osmotic pressure. All these observations emphasise the correctness of Graham's dictum "that a liquid transpiration tube [i.e. a viscometer] may be employed as a colloidoscope."

T. M. L.

364. Experimental Determinations of Drop-electrode Potentials in Mixtures of Water and Alcohol. H. Krumreich. (Zeitschr. Elektrochem. 19, pp. 622-686, Aug. 15, 1918.)—The arrangement is described in detail. The jet is on the Paschen plan, the separation into drops beginning in the level of the liquid, and the observations are checked by measurements with the capillary electrometer. When the liquid above the mercury is water, some depolarisation of the jet potential, by diffusion and convection owing to the slight solubility of mercurous salts in water, will take place even on the Paschen plan; but it is much smaller when alcohol, of different concentrations, is used in the place of water. The author determines this depolarisation and then the potentials in alcoholic solutions of KNO_3 of various concentrations.

H. B.

365. A New Grove Cell. K. Sieg1. (Elektrotechn. Zeitschr. 84, pp. 1817-1818, Nov. 18, 1918.)—Briefly reviewing the extensive literature on Grove cells and his own experiments with cells consisting of Pt electrodes, coated with platinum black and dipping into sulphuric acid, the one surrounded by hydrogen, the other by oxygen (or other gases), the author comes to the following conclusion. Immediately after closing the circuit all the parts are active in generating electricity; the occluded gas is consumed, and new gas is absorbed by the portion of the electrode above the liquid, whilst the

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portion within the liquid becomes polarised with respect to the upper portion, and the e.m.f. decreases. The electrodes should hence have large surfaces and should discontinuously be brought into contact with a diaphragm, which forms the gas chamber and which is moistened with the electrolyte. The scanty descriptive details offered hardly explain how this is realised in the new cell. The electrodes are platinised grains of carbon, 8 mm. in diam., and carbon plates in shallow clay cylinders charged with the gas and with sulphuric acid (hydrochloric acid, when chlorine gas is used). Cells of this type are said to be economical: Cl-H cells give 1.4 volts at an expenditure of 0.48 mark per kw.-hour, O-H cells 0.9 volt at 0.85 mark and air-illuminating gas cells 0.7 volt at 0.17 mark. Pressure, from 1 cm. of mercury to 5 atmos., does not influence either the e.m.f. or the current. The cells are supplied by C. Schniewindt, of Neuenrade, Westphalia. H. B.

366. Electrolytic Sodium Hypochlorite with Cooled Anode. P. H. Prausnitz. (*Zeitschr. Elektrochem.* 19. pp. 676-680, Sept. 1, 1918.)—Working with a tubular Pt anode consisting of an inner tube and a jacket, through both of which water is flowing in series, the author finds that in 5-nNaCl solutions the yield of hypochlorite was 41.6, 90, and 100 gm. of Cl per litre respectively, when the anode was left uncooled or cooled to 16° or to 4° C. Such energetic cooling is, however, not required, provided the anode is kept at about 20°, whilst the electrolyte warms up to 48°; up to 70 gm. Cl are then gained. When the brine contains the normal NaCl solution, cooling is of little avail. The current density should be about 1.25 amps./cm.². The yield can further be raised by platinising the anode. H. B.

367. Valve Action of Zirconium Anodes. L. H. Walter. (*Electrician*, 71. pp. 1057-1058, Oct. 8, 1918.)—Zirconium anodes have been prepared from small crystals of Zr, a surface of 8 mm. by 2 mm. of zirconium being left exposed. Using these electrodes as anodes, it is shown that the ratio of the resistance in the effective direction to that in the non-effective direction is of the order 10⁴. A series of measurements of the leakage current at various potentials is given for solutions of 8 % sulphuric acid, sodium tungstate, lithium citrate, ammonium borate, potassium dichromate, and sodium carbonate. In the case of sulphuric acid the valve action breaks down at about 105 volts, whilst in other solutions a higher potential can be applied without destroying the valve action. As in the case of tungsten [see Abstract No. 2152 (1909)], zirconium is very sensitive to the cutting off of the current. The question as to whether rectification occurs on alternating current is not yet decided. Zirconium is the only metal of the fourth group of the periodic system which has been shown to exert a valve action. L. H. W.

368. Ultramicroscopic Investigations of the Cataphoresis of Colloidal Solutions: A Theory of Coagulation. M. Kimura. (*Kyōtō Coll. Sci. Engin.*, Mem. 5. pp. 175-199, May, 1918.)—The author has made ultramicroscopic investigations on an electrolytic cell constructed by placing two pieces of Pt-wire, 20 μ in diam., in parallel positions a fraction of a mm. apart, on a clean plate of fused silica or glass, introducing a drop of colloidal silver solution between the wires and covering with another quartz or glass plate; a current was passed through the liquid under observation. From the results obtained the following conclusions are drawn:—The electric double layer covering a colloidal particle remains undissociated in an ordinary state; the dissociation of double layers, and, consequently, the translational motion of

colloidal particles, occurs only by the current motion of electrolytic ions. In their motion towards the electrodes dissociated colloidal particles collide with electrolytic ions and undergo variations in the amounts of the charges carried. When the current is cut off, particles soon become covered again with double layers. When an electric current flows through a colloidal solution, part of this current is generally carried by colloidal particles. When an electric current is sent through a solution containing so-called negative colloids, some of these change into positive ones. In a colloidal solution prepared by Bredig's method the charge possessed by the dissociated particles varies from particle to particle. When a current passes through a colloidal solution, the aggregation and coagulation of particles take place among the oppositely charged dissociated particles when these approach one another very closely. The first stage in the coagulation of a colloidal solution by an electrolyte is the formation of the positive and negative colloidal particles, the second stage being the union of the different particles thus formed. The coagulation of a platinum hydrosol is caused easily by the bubbling of oxygen, but not by that of hydrogen, through the liquid.

T. H. P.

369. *Electrolysis of Potassium Chloride.* H. S. Lukens. (Amer. Chem. Soc., Journ. 85. pp. 1472-1482, Oct., 1918.)—In the electrolytic estimation of anions, using the Hildebrand cell, only small quantities of salt can be used. The author has investigated the accuracy which is obtainable when solutions of potassium chloride containing 1-2 gm. of the salt are electrolysed. It was found that the chief error was caused by the anolyte creeping into the catholyte under the glass partition (cup) separating the anolyte and catholyte, owing to the fact that glass is not wetted by mercury. This could be prevented by platinising the bottom edge and outside of the cup, and then depositing a heavy coating of silver on the Pt. There was still a slight error caused by some decomposition of the amalgam occurring in the inner cell. This was obviated by cutting a section, 8 mm. in height, from the bottom of a beaker 40 mm. in diam.; this was cemented in an inverted position in the centre of the crystallising dish containing the mercury. When the glass cup was then placed in position the mercury in the anode portion of the cell was confined to an annular space, about 10 mm. wide, between the cup and the section from the beaker, whereby the amalgam was formed close to the outer vessel, into which it quickly made its way and was decomposed. The results obtained with this apparatus were very accurate, the errors being of the order of 0.0001-0.0008 gm. on 0.6 gm. of chlorine. 1.09 gm. of potassium chloride could be decomposed in an hour, using 1.6-2 amps. at 6.5-7 volts.

T. S. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

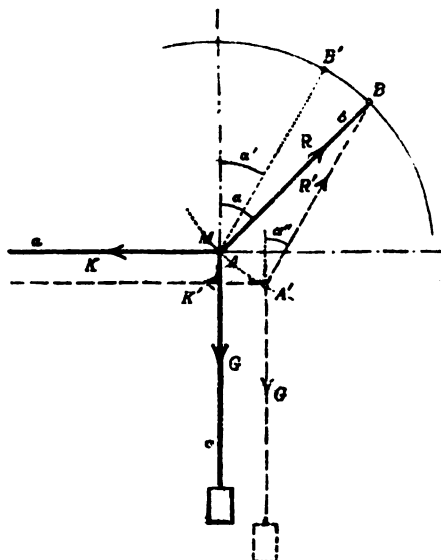
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GENERAL PHYSICS.

370. *Schilowsky Gyroscopic Monorail Car.* (Engineer, 117. pp. 106-107, Jan. 28, 1914.)—A model of this car is at present at the Imperial College of Science, South Kensington, and is intended for demonstration purposes. A larger example of the system capable of accommodating six passengers is nearly completed. The gyroscopic axis is vertical and two pendulums are provided for automatically controlling the gyroscope. Thus, if the car lurches to the right, the left-hand pendulum pulls a cord and so puts a rack and pinion into mesh. This, in turn, gives such an action on the gyroscope as to call forth for it the desired righting torque and so balance the car. E. H. B.

371. *Some Improvements in the Bimetallic Actinometer.* W. Michelson. (Meteorolog. Zeitschr. 80. pp. 577-580, Dec., 1918.)—The author describes certain improvements of detail in his bimetallic actinometer described in Abstract No. 1897 (1908). It had been found that while certain of the instruments in the hands of careful observers gave quite satisfactory and accurate results, other instruments appeared to be very variable in their indications. The improvements tend to render the actinometer less liable to misuse by an unpractised observer. The principle of the instrument is that the sun is allowed to shine through a movable cover upon a small bimetallic plate ($11 \times 1.7 \times 0.05$ mm.) of iron and invar. The increase of temperature communicated to the plate is shown by a bending of the plate, the amount of which is indicated by a light pointer of Al fixed to the plate and observed through a microscope provided with a suitable scale. The principal improvement consists in the reduction of the size of the plate to that given above, as it was found that the weight alone of the former plate was sufficient to produce an appreciable amount of bending when the instrument was directed towards parts of the sky which differed appreciably in altitude. The instrument now appears to give remarkably accurate results, and the scale value remains nearly invariable when tested by means of a standard Ångström pyrheliometer. R. C.

372. *Instrument for Measuring Forces.* K. Schmiedel. (Zeitschr. Instrumentenk. 88. pp. 878-875, Dec., 1918.)—Describes an instrument designed for measuring forces of from 0.2 gm. to 50 gm. weight, the principle of the parallelogram of forces being utilised. The three threads (cocoon fibres) a , b , and c , are fastened together at A . The force K to be measured is applied to a ; a weight G is attached to c ; the end B of the thread b , which takes the



resulting reaction, can be moved along a circular scale. In correct adjustment the point A coincides with the centre M of the circular scale. If K and G are at right angles to one another, then $K = G \tan \alpha$. If K now varies to a value K' , and remains horizontal, the same weight G being used, the point A moves to a new position A' . B is then moved until A once more coincides with M . A photograph of the actual instrument is given, with particulars of the construction and method of adjustment. A. W.

373. *Densities of Dilute Aqueous Solutions by a New Method.* A. B. Lamb and R. E. Lee. (Amer. Chem. Soc., Journ. 85. pp. 1666-1698, Nov., 1918.)—In order to measure the relative densities of aqueous solutions to eight places of decimals a glass float was used, which could be loaded by Pt weights of 1 mgm. dropped into a hollow at the top of the float. The float was totally submerged in the liquid to be tested, and the final adjustment of buoyancy was made by the action of an electromagnetic field on a piece of soft iron enclosed in the float. In making an observation the float was drawn down until a Pt point at the bottom of the float occupied a central position in a cup at the bottom of the liquid; the current in the coils was then reduced until the point just escaped from contact, as observed by means of a microscope immersed in the solution. The weight of the bulb *in vacuo* was 284.5681 gm. It displaced 285.1069 cm.³ of water at 20.004° on the hydrogen scale. The electromagnetic effect was found to be 0.04772 ± 0.00014 mgm. per milliamp. and enabled readings of buoyancy to be taken to 0.02 mgm. or about 0.00000008 gm./cm.³ in the density. In comparing very dilute solutions with

pure water it was only necessary to be sure that the temperatures were identical: by immersing everything in a big thermostat the temperature-variations were reduced to 0.001° , or $\pm 0.0005^\circ$, equal to 0.0000009 in the density. The max. error from all sources was calculated to be 0.0000008 , but in practice it was found to be about one-tenth of this, and under favourable conditions might be 5 or 10 times less.

By this method solution-volumes can be measured accurately for solutions from 0.01 to 0.0001 gm. equivalents per litre; even in the most dilute of these solutions the errors appeared in practice to be only about 0.1% . T. M. L.

374. *Specific Gravity and Displacement of Saline Solutions.* J. Y. Buchanan. (Roy. Soc. Edinburgh, Trans. 49. No. 1. pp. 1-227, 1912-1918.)—A minute description is given of experiments on the density and displacement of saline solutions by means of accurate hydrometers. Data are given which show that in a series of observations two experimenters can obtain results differing on the average by about 0.000006 , i.e. about the same degree of accuracy as that attained with Bousfield's larger pycnometers. In contrast with the American workers, Lamb and Lee [see preceding Abstract], who have succeeded in measuring the densities of dilute solutions to nine significant figures, the author uses a hydrometer with an exposed stem and works at room-temperature without using a thermostat of any kind. On the other hand, he has been able, by using an open in place of a closed hydrometer, to load the instrument with additional mercury and to extend the observations even to supersaturated solutions of calcium chloride; these solutions showed remarkable oscillations of density prior to crystallisation. The unsaturated solutions examined were chiefly chlorides, bromides, iodides, nitrates, chlorates, bromates, and iodates of potassium rubidium, and caesium.

For data and results the original paper must be consulted. T. M. L.

375. *Determination of Mineral and Rock Densities at High Temperatures.* A. L. Day, R. B. Sosman and J. C. Hostetter. (Amer. Journ. Sci. 87. pp. 1-89, Jan., 1914.)—After reviewing existing and rather conflicting data on the change in volume on fusion of various rocks, the authors describe apparatus by which the volume of metals and of solid and liquid silicates can be determined from 250° to 1600° . The sensitiveness of the method is from 0.08 to 0.2 per cent. The accuracy varies with the metal used, the temperature, and the size of the sample, but is usually between 0.2 and 0.5 per cent. The fundamental constant is the expansion coefficient of artificial graphite. Volume measurements on quartz up to 1600° show a dilatation which increases rapidly as the inversion point of 575° is approached. Above this temperature quartz contracts slightly. At about 1800° there begins a second and irreversible dilatation due to the formation of cristobalite. Owing to the unequal expansion of the various minerals the rock is fractured, so that the true volume-change over any considerable range cannot be obtained from natural rocks. L. H. W.

376. *Change in Elasticity of a Copper Wire with Current and External Heating.* H. L. Dodge. (Phys. Rev. 2. Ser. 2. pp. 481-449, Dec., 1918.)—Describes experiments on the change of Young's modulus for a copper wire when heated (i) by an external source, and (ii) by the passage of an electric current through the wire. The object of the experiments was to discover if there was any difference in the changes produced by the two methods of heating. Preliminary work showed that there were no sudden changes

in the elastic state of the wire, and that rapidity of heating or cooling, or the length of time for which a given temperature was maintained, had very slight effect. The method of experiment is described and modulus-temperature curves are drawn, embodying the results of a large number of determinations made over the range from 20° to 150° C. The wire was taken repeatedly backwards and forwards over the whole range, and the closeness with which the curve returns on itself shows the absence of any hysteresis or history effects. The curves for the same specimen of wire under the two methods of heating are practically identical, and it is hence concluded that the passage of a current along a copper wire has no other effect on Young's modulus than that due to the consequent change of temperature. The modulus, in both cases, decreases at a growing rate with rise of temperature. Experiments are in progress with iron and other metals. J. W. T. W.

377. Tungsten Wire Suspensions for Magnetometers. S. Chapman and W. W. Bryant. (*Nature*, 92, p. 585, Jan. 22, 1914).—Tungsten wires of 20 microns diam., such as are used in metallic filament lamps, have been adopted instead of silk or quartz for suspending a declination magnet weighing 50 gm. The effect of 90° torsion was to turn the magnet through $4'$. With this wire, the zero does not change within the limits of measurement, and the wire can be obtained at 8d. per foot. G. E. A.

378. Determination of the True Stresses during Tensile Tests at any desired Temperature. F. Hauser. (*Deutsch. Phys. Gesell., Verh.* 15. 24. pp. 1278–1800, Dec. 80, 1918).—A photographic method of determining the change of section of a bar under tensile loads at various temperatures has been worked out. The test-piece and shackles are enclosed in a square box which can be heated up to 210° C. by means of a current of hot air from a side-chamber. Two adjacent sides of the box are illuminated, while photographs of the bar can be taken through windows in the other sides. Preliminary tests on solder (78.78 % Sn and 20.62 % Pb) showed that the method was quite reliable for recording simultaneous loads and changes of section in materials undergoing considerable deformation under stress. Tests made on pure zinc showed that at low temperatures the stress calculated on the original section differed very little from the true stress (calculated on the reduced area). Fracture commences as soon as the max. load is attained, and is propagated rapidly across the whole section, so that very little contraction occurs and the max. load and tensile strength are equal. At higher temperatures, however, the fracture takes place more slowly; the true stress attains its maximum some time before breakage occurs, resulting in a greater amount of deformation which increases with the temperature. Mean values show that pure zinc loses its strength slowly up to 60° C. and then more rapidly as the temperature rises. During the whole period the elongation gradually increases. There is no minimum strength and max. elongation at 150° C. such as would be expected from the behaviour of "rolling" zinc at this temperature. The difference in properties between pure and technical zinc in this respect is ascribed to the presence of impurities in the latter. Tin shows 100 % contraction at all temperatures, so that the true stresses had to be determined by continuing the stress-strain diagrams to 100 % contraction. These values, plotted in terms of the temperature, show that the strength of tin up to 210° C. decreases along a logarithmic curve showing a true stress of 800 kg./cm.² at 0° C. The elongation rapidly attains a max. value at 60° C., after which it diminishes slowly with increasing temperature. F. C. A. H. L.

379. Method for Measuring the Pressure produced in the Detonation of High Explosives or by the Impact of Bullets. B. Hopkinson. (Roy. Soc., Phil. Trans. 218. pp. 487-456, Jan. 81, 1914.)—The determination of the actual pressures produced by a blow such as that of a rifle bullet or by the detonation of high explosives, is a problem of much scientific and practical interest but of considerable difficulty. It is easy to measure the transfer of momentum associated with the blow, which is equal to the average pressure developed multiplied by the time during which it acts, but the separation of these two factors has not hitherto been effected. The direct determination of a force acting for a few hundred-thousandths of a second presents difficulties which may perhaps be called insuperable, but the measurement of the other factor, the duration of the blow, is more feasible. In the case of impacts such as those of spheres or rods moving at moderate velocities, the time of contact can be determined electrically with considerable accuracy [see Abstract No. 1988 (1907)]. The present paper contains an account of a method of analysing experimentally more violent blows, and of measuring their duration and the pressures developed. The theoretical basis of the method receives elaborate exposition in the paper. If a rifle bullet be fired against the end of a cylindrical steel rod there is a definite pressure applied on the end of the rod at each instant of time during the period of impact, and the pressure can be plotted as a function of the time. The pressure-time curve is a perfectly definite thing, though the ordinates are expressed in tons and the abscissæ in millionths of a second. The result of applying this varying pressure to the end is to send along the rod a wave of pressure which, so long as the elasticity is perfect, travels without change of type. If the pressure in different sections of the rod be plotted at any instant, then at a later time the same curve shifted to the right by a distance proportional to the time will represent the then distribution of pressure. As the wave travels over any section of the rod, that section successively experiences pressures represented by the successive ordinates of the curve as they pass over it. The progress of the wave of stress along the rod is accompanied by corresponding strain and therefore by movement, the same curve which represents the distribution of pressure at any moment also representing the distribution of velocity in the rod. When the wave reaches the free end of the rod it is reflected as a wave of tension which comes back with the same velocity as the pressure-wave, and the state of stress in the rod subsequently is to be determined by adding the effects of the direct and of the reflected waves. The author takes the case of a rod divided at some section near the free end, the opposed surfaces of the cut being in firm contact and carefully faced. The wave of pressure travels over the joint practically unchanged, and pressure continues to act between the faces until the reflected tension wave arrives at the joint. The pressure is then reduced by the amount of the tension due to the reflected wave, and as soon as this overbalances at the section the pressure of the direct wave, the rod, being unable to withstand tension at the joint, parts there and the end flies off with a quantity of momentum which may be measured by a ballistic pendulum. By taking end-pieces of different lengths and measuring the momentum so trapped in each, the area of the pressure-time curve over corresponding intervals can be obtained. In general the precise form of the curve itself cannot be deduced because the points of commencement of the several intervals are not known, but the max. pressure and the total duration of the impact can always be obtained. The max. pressure is the limiting value of the average acting on a piece when the piece is very short, and the duration corresponds to twice that

length of piece which just catches the whole of the momentum, leaving the rod at rest. This is the basis of the method described in the present paper. A cylindrical rod or shaft of steel is hung up horizontally by four equal threads, so that it can swing in a vertical plane remaining parallel to itself. A short piece of rod of the same diam. is butted up against one end, being held on by magnetic attraction but otherwise free. A rifle bullet is fired at, or gun-cotton is detonated near the other end; the short piece flies off and is caught in a box suspended in a similar manner to the long rod. Suitable recording arrangements register the movement both of the long rod and of the box, and the momentum in each is calculated in the usual way as for a ballistic pendulum. Sufficient magnetic force to hold the end-piece in position is provided by putting a solenoid round the rod in the neighbourhood of the joint. The slight force required to separate the piece from the rod under these conditions may be neglected in comparison with the pressures and tensions set up, since these amount to several tons on the square inch; and practically speaking, the joint will transmit the pressure wave unchanged but will sustain no tension.

The pressure produced by the impact of lead bullets is first recorded, since this may be predicted theoretically and so serve as a check for the method. At velocities exceeding 1000 ft. per sec. lead behaves on impact against a hard surface practically as a perfect fluid. Most of the experiments were made with the service cartridge, in the service rifle, giving an average velocity of 2000 ft. per sec. Tables, curves, and discussion of results then follow. The effect of the rigidity of the bullet next receives attention. In the simple theory it is assumed that the bullet is absolutely fluid, but corrections have to be made owing in part to a certain rigidity due to the nickel casing, and in part to the viscosity of lead, the effect of which may be quite appreciable at such high speeds of deformation. A discussion is then given of errors inherent in the method of experiment. Experiments were also undertaken at lower velocities, and a table of results is given. The author finally deals with the detonation of gun-cotton, experiments being made with the method above described which, although only giving approximate results owing to the quite small charges used, yet throws light on a matter of which little is known. The author concludes that the most probable account of the smashing of a mild-steel plate is that the plate is cracked before it has appreciably deformed, the cracks being caused by relative velocity given impulsively to different parts of the plate. Bending of the broken pieces occurs after the plate has cracked and the pieces have separated from one another, and is due to relative velocity in different portions of each piece, which still persists after the initial fracture and is taken up as a permanent set in each piece. The author is of opinion that his experiments on gun-cotton pressures supply sufficient evidence that the blow may be regarded as an impulsive force communicating velocity instantaneously. Several tables, diagrams, and photographs illustrate this particular section.

H. H. Ho.

380. *Effects of the Detonation of Gun-cotton.* B. Hopkinson. (Engineering, 97. pp. 199-201, Feb. 6, 1914. Paper read before the N.E. Coast Inst. of Engin. and Shipbuilders, Jan. 80, 1914. Roy. Soc., Proc. Ser. A. 80. pp. 411-418, Jan. 1, 1914. Abstract.)—The paper contains an account of experimental methods for measuring the pressure produced by the detonation of explosives [see also preceding Abstract]. At the outset the author gives an outline of the mechanism of explosion, referring to A. Noble's work on the pressure developed; the latter's work was limited to the less powerful explosives owing to the fact that no measuring apparatus was available which could

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withstand these pressures without damage. A short description of the practical effects produced by the pressure developed during the detonation of explosives is then given. When gun-cotton is detonated in the open without tamping of any kind, a highly-ductile mild steel under this particular type of stress behaves like a brittle body. There is usually some distortion of the broken pieces of the plate; but there is reason to suppose that this occurs after the fracture, and that the immediate effect of the blow is to shatter, as though it were cast-iron, a material which in a press can be bent double without showing a crack. The author claims this action to be well worthy of further study by all engineers, because of the light which such study may throw on the properties of the material with which they work. From this point of view the author approaches the subject for devising a means of analysing the blow given by the detonation of gun-cotton. Details of the method then follow for which see also the other paper referred to (*loc. cit.*). H. H. HO.

381. *The Supposed Relation between Elasticity and the Heat of Fusion of Metals.* F. Lejeune. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 789-749, April, 1918.)—The author shows that Guldberg's relation between the elasticity coefficient, E , the density, d , and the latent heat of fusion, λ , of metals, namely $E = 40d\lambda$, gives better results for the metals Pb, Zn, Ag, and Cu when the numerical coefficient is changed to 88; the relation does not hold for alloys, cast-iron, and Pt. For drawn wires, better results are obtained if, instead of the latent heat of fusion, the total heat of fusion (Q), reckoned from the temperature at which the elasticity modulus is determined, is taken; the relation $E = 10Q$ then gives good results. Theoretical considerations indicate that instead of an alteration in length, an alteration in volume should be taken into account, and the author finds in the case of 16 metals, including alloys, the relation $s^2/E^3 = \text{const.}$, gives good results, where s is specific tension at the elasticity limit. T. S. P.

382. *On the General Theory of Elastic Stability.* R. V. Southwell. (Roy. Soc., Phil. Trans. 218. pp. 187-244, Aug. 6, 1918.)—The paper is mainly mathematical and treats of the theory of the stability of boiler-flues and tubular struts; the experimental portion has already been dealt with [Abstract Nos. 7 and 1241 (1918)]. The treatment is given under the headings: Equations of neutral equilibrium in rectangular and in cylindrical co-ordinates. General theory of instability in materials of finite strength. L. H. W.

383. *The Measurement of Stresses in Materials and Structures.* E. G. Coker. (Soc. Arts, Journ. 62. pp. 128-138, Jan. 2; 144-153, Jan. 9, and pp. 162-172, Jan. 16, 1914. Mech. Eng. 88. pp. 88-96, Jan. 28; 107-110, Jan. 30; 180-188, Feb. 6, and pp. 150-158, Feb. 18, 1914.)—Deals with general methods, and then very fully with the application of the optical method of testing by means of double-refraction made evident by plane-polarised light [see Abstracts Nos. 776, 1627 (1912), and 820, 906 (1913)]. L. H. W.

384. *Application of Graphical Methods to the Solution of Problems on Struts and Tie-rods with Lateral and Non-axial Loads.* C. H. Lander. (Phil. Mag. 27. pp. 208-218, Jan., 1914.)

385. *Fourier Analysis.* F. W. Grover. (Bureau of Standards, Bull. 9. pp. 567-646, Dec. 15, 1918.)—By his method of grouping similar terms Runge has greatly simplified harmonic analysis. The object of this paper is

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still further to lessen the labour of analysing curves and more especially to facilitate the analysis of alternating current waves. The arrangement of the calculation is given in detail for three special cases, namely, for 6, 12, and 18 measured ordinates per half-period. Useful equations are also given for checking the accuracy of the results obtained. Numerical examples are given which show clearly that when higher harmonics are present a considerable number of ordinates must be measured in order to secure accuracy. The value of harmonic analysis for computing average and effective values, average power, etc., is pointed out. In the Appendix several valuable schedules and tables for use in Fourier analysis are given. A. R.

386. *Stability of the Laminar Motion of an Inviscid Fluid.* Rayleigh. (Phil. Mag. 26. pp. 1001-1010, Dec., 1918.)—A mathematical treatment of the subject, with applications to (i) the case (considered by Orr) of a simple shearing motion between two walls with a composite disturbance, periodic with respect to x but not with respect to t ; (ii) the disturbance due to a single vortex filament in which the vorticity differs from the otherwise uniform vorticity of the neighbouring fluid. A. W.

387. *The Flow of Air through Capillary Tubes.* I. M. Rapp. (Phys. Rev. 2. Ser. 2. pp. 868-882, Nov., 1918.)—Describes experimental determinations, by the capillary tube method, of the absolute coefficient of viscosity of air (η), every endeavour being made to eliminate all sources of possible error by (i) the selection of very uniform tubes and their thorough cleansing and accurate calibration; (ii) the use of a considerable number of tubes of different dimensions; (iii) the use of small, constant, and accurately measured driving pressures; and (iv) the experimental study of the end correction. The value of the radius (R) to be used for each tube in calculating from Poiseuille's formula was obtained from calibration by the method used by Fisher [Abstract No. 661 (1909)], while corrections were applied for the shape of the meniscus and for slip. Different values of η were obtained by using different driving pressures on the same tube or different tubes at the same driving pressure, these differences being due to the energy in the stream-lines at the ends of the tubes. Corrections for this effect were applied by Brillouin's and by Fisher's methods, both formulæ giving good agreement within the assigned limits of experimental error. Special experiments with three different lengths of a wider tube, however, gave a superiority for Fisher's formula. In the final deduction of the value of η use was made only of those values given by tubes in which the end correction was small, and the mean of the corrected values obtained by both formulæ was taken as the true value. This is given as 1887.5 (10') gm./cm. sec. for dry air at 29° C., with an estimated error of 0.1 %. This value agrees with most determinations made by other methods. J. W. T. W.

388. *Hydrodynamical Actions of Vibrating Air on Two Spheres.* G. Thomas. (Ann. d. Physik, 42. 6. pp. 1079-1098, Dec. 28, 1918. From Dissertation, Giessen).—The aerial oscillations are produced by a cylinder mounted on one prong of an electrically maintained tuning-fork of frequency 81 per sec. The spheres under examination are within the vibrating cylinder, and the forces between are measured by a torsion balance, their distance and motion being observed microscopically. The experiments show that the forces have always the directions that the

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theory gives for non-viscous fluids. For distances apart less than the radius of the spheres, however, the equatorial repulsions and axial attractions were never observed.

E. H. B.

389. Viscosity of the Atom. L. Décombe. (Journ. de Physique, 8. Ser. 5. pp. 869-881, Nov., 1918.)—The general theory previously developed is here applied to the viscosity of the atom which is assimilated to an assemblage of little dynamical systems, each formed of a certain number of electrons describing the same orbit under the action of a central force proportional to the distance. [See Abstracts Nos. 1015 and 1898 (1918).]

E. H. B.

390. Relativity Dynamics of Homogeneous Bodies. K. Schaposchnikow. (Ann. d. Physik, 42. 6. pp. 1572-1574, Dec. 28, 1918; and M. v. Laue, pp. 1575-1579, Dec. 28, 1918.)—Mathematical discussions.

E. H. B.

391. Atomic Structure. J. J. Thomson. (Phil. Mag. 26. p. 1044, Dec., 1918.)—In his recent paper [Abstract No. 14 (1914)] the author supposed that the regions within which the electrical forces inside the atom were supposed to be confined were bounded by conical surfaces. Further investigation shows that the period of a corpuscle inside the region would increase with its energy, and the corpuscle would cease to be in unison with the light before it had acquired enough energy to escape from the region of electrical force. If, however, the boundaries were cylindrical, the period would be independent of the kinetic energy of the corpuscle. The latter would then be in resonance with the light until it had acquired enough energy to escape. Assuming cylindrical surfaces, the results of the paper can apply without further modification.

G. W. DE T.

392. Atomic Dimensions and Constitution. A. Heydweiller. (Ann. d. Physik, 42. 6. pp. 1278-1286, Dec. 28, 1918.)—Determinations of atomic dimensions (1) from the mean free path of a molecule in the normal gaseous state, (2) from the Lorenz-Lorentz refraction equivalents, are compared. Except for monatomic gases, the latter method is susceptible of far less accuracy than the former, but the atomic diameters determined by the two methods do not vary more than 2 % from the means 1.668×10^{-8} for H, 2.765×10^{-8} for Cl, and 8.185×10^{-8} for Xe. For the lower terms of the series of noble gases the discrepancies much exceed the limits of experimental error, and suggest the necessity for a modified theory. The general results are consistent with Kelvin's theory of the atom and with Weiss's magneton theory. They do not support Langevin's diamagnetic theory, which, moreover, requires an improbably large number of electrons in the atom. The ratio of apparent to the true space occupied by the atoms of metals in the solid state leads to a remarkable division into groups, according to the value of the fraction $(M_s - A_s)/A_s$, where M_s is the ratio of atomic weight to density, and A_s is the actual space occupied, as determined by the Lorenz-Lorentz atomic refraction. The values of this fraction as obtained by the author are shown in the accompanying table.

Li 6.48	Mg 4.80	Zn 1.07	Cu 0.615	Mn ^{..} 0.819
Na 9.17	Ca 4.29	Cd 1.00	Ag 0.585	Fe ^{..} 0.879
K 9.81	Sr 4.77		Th 0.497	Co ^{..} 0.805
Rb 8.81	Ba 8.18		Pb 0.871	Ni ^{..} 0.481
Cs 7.60				
Means 8.26	4.12	1.04	0.504	0.857

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G. W. DE T.

393. Change with Temperature in Crystal-angles of Quartz. F. E. Wright. (Washington Acad. Sci., Journ. 8. pp. 486-494, Dec. 4, 1918.)—The rhombohedral angle of quartz decreases with rise of temperature up to 575° from 51° 47·4' to 51° 86·7'. The values agree within 0·1' with those calculated (a) from the coefficient of expansion, parallel to the axis and the change of specific volume of the material, and (b) from the exponential formula—

$$\gamma = 51^\circ 47'4'' [0.0118178t + 0.01885(e^{\frac{t}{1000}} - 1)]$$

Beyond 575°, at which temperature an inversion takes place, the angle, after showing an abrupt increase, remains almost constant from 600° to 1200°. In taking readings at the highest temperatures it was necessary to use an arc-light to secure a reflected image from the faces, the glow from the furnace being cut off by means of a blue filter.

T. M. L.

394. Gravitation. M. Grossmann. (Archives des Sciences, 87. pp. 18-19, Jan., 1914.)—Deals with mathematical methods and problems relative to the theory of gravitation, the analysis being vectorial.

E. H. B.

395. Gravitation. A. Einstein. (Archives des Sciences, 87. pp. 5-12, Jan., 1914. Phys. Zeitschr. 14. pp. 1249-1262; Discussion, pp. 1262-1266, Dec. 15, 1918, and 15. pp. 108-110, Jan. 15, 1914. Paper read before the 86. Naturforscherversamml., Wien.)—Discusses a possible physical basis of the theory of gravitation with reference to the principle of relativity, and specially on the view that an apparent gravitational field may be replaceable by a state of acceleration of the frame of reference. Part of the paper is mathematical.

E. H. B.

396. Dependence of the Capillary Constants of Water and Alcohol-Water Mixtures on the Temperature. M. Reinhold. (Deutsch. Phys. Gesell., Verh. 15. No. 19. pp. 908-912, Oct. 15, 1918. Extract from Dissertation, Kiel.)—The method employed to determine the capillary constant consists in measuring the wave-length of the capillary waves produced on a freshly-prepared surface of the liquid by means of a vibrating tuning-fork. With the aid of a reading microscope devised by Grunmach the wave-length can be measured to within 0·01 mm. For five mixtures of ethyl alcohol and water containing respectively 94, 70, 50, 30, and 10 per cent. of the alcohol, the dependence of the capillary constant on the temperature between 0° and 65° is expressed by the linear equation, $\alpha = \alpha_0 (1 - \epsilon t)$, where ϵ is the temperature-coefficient. The values of ϵ are 0·000080, 0·000098, 0·000105, 0·000186, and 0·000206 respectively. In the case of water, the method used gives an irregular curve.

T. H. P.

397. Capillarity, Vaporisation and Molecular Size. G. Jäger. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 969-978, May, 1918.)—A mathematical paper in which justification is found for the Thomson method of determining molecular size and for the conclusions drawn by Stefan regarding the relationship between capillarity and vaporisation. The result obtained by the author is also of importance for the determination of size of drops from the velocity of fall of drops in air.

A. F.

398. Meteorological Observations, and Observations at Various Strata of the Atmosphere, obtained on the Lightship "Luzerort." M. Rykatchew. (Acad. Sci. St. Pétersbourg, Bull. 1. pp. 28-40, Jan. 15, 1914. In Russian.)—An account is given of observations taken in the period Aug. 12-24, 1913, on the lightship, which is situated at 57° 88' N. lat. and 21° 88' E. long. (of Greenwich).

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TIME,

Temperature of Air, °C.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
By thermograph Kuznatsof	15.1	14.8	14.7	14.9	14.7	14.9	15.0	15.2	15.5	15.7	16.0	16.0	16.1	16.2	16.3	16.4	16.2	16.2	16.2	16.1	16.2	15.9	15.8	16.0
By psychr. Ass. at 6 m. ...	—	—	—	—	—	—	—	15.1	15.3	15.6	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.5	16.4	16.3	16.2	16.2	—	—
By psychr. Ass. at 4 m. ...	—	—	—	—	—	—	—	15.4	15.5	15.8	16.2	16.3	16.3	16.5	16.5	16.7	16.9	17.0	16.7	16.6	16.4	16.5	—	—
By psychr. Ass. at 1-5 m.	—	—	—	—	—	—	—	15.4	15.5	15.8	16.0	16.1	16.1	16.3	16.4	16.7	16.9	17.0	16.8	16.6	16.4	16.4	—	—

Temperature of Water, °C.

Surface (mean 8 days) ...	—	—	—	—	—	—	16.0	—	16.1	—	16.1	—	16.2	—	16.3	—	16.3	—	16.2	—	16.0	—	—	—
Surface (mean 10 days) ...	—	—	—	—	—	—	16.0	—	16.1	—	16.2	—	16.2	—	16.2	—	16.2	—	16.2	—	16.0	—	—	—
Depth 15 ft. (mean 8 days)	—	—	—	—	—	—	16.0	—	16.1	—	16.1	—	16.2	—	16.2	—	16.2	—	16.2	—	16.0	—	—	—
Depth 15 ft. (mean 10 days)	—	—	—	—	—	—	16.0	—	16.0	—	16.1	—	16.2	—	16.2	—	16.2	—	16.1	—	16.0	—	—	—
Depth 80 ft. (mean 8 days)	—	—	—	—	—	—	16.1	—	16.1	—	16.1	—	16.2	—	16.2	—	16.3	—	16.2	—	16.2	—	—	—
Depth 80 ft. (mean 10 days)	—	—	—	—	—	—	16.1	—	16.1	—	16.0	—	16.2	—	16.2	—	16.2	—	16.2	—	16.1	—	—	—
Depth 45 ft. (mean 8 days)	—	—	—	—	—	—	15.0	—	14.9	—	14.9	—	15.4	—	15.6	—	15.8	—	15.7	—	15.7	—	—	—
Depth 45 ft. (mean 10 days)	—	—	—	—	—	—	14.1	—	14.0	—	14.1	—	14.5	—	15.2	—	15.1	—	14.9	—	14.9	—	—	—
Depth 60 ft. (mean 8 days)	—	—	—	—	—	—	14.8	—	14.8	—	14.7	—	14.8	—	15.5	—	14.9	—	14.7	—	14.8	—	—	—
Depth 60 ft. (mean 10 days)	—	—	—	—	—	—	13.8	—	13.8	—	13.8	—	14.0	—	14.7	—	14.2	—	14.0	—	14.1	—	—	—

In addition to the usual observations, the temperatures of the water at depths of 15, 80, 45, and 60 ft. were regularly measured. Further, by the use of kites, records of temperature, humidity, and wind velocity were

DAILY COURSE OF THE ELEMENTS REGISTERED BY KITE FLIGHTS,
AUG. 22, 1918.

Time	Temp. °C.	Humidity, %	Velocity of Wind, m./sec.	Time	Temp. °C.	Humidity, %	Velocity of Wind, m./sec.	Time	Temp. °C.	Humidity, %	Velocity of Wind, m./sec.
h. m.	6 M.			h. m.	100 M.			h. m.	500 M.		
9 30m	16.0	91	7	9 35m	16.0	93	7	9 47m	11.7	97	7
10 58	16.2	92	8	10 56	15.1	94	8	10 50	11.8	99	7
1 37a	16.5	89	7	1 41a	15.6	90	7	1 56a	12.1	95	8
3 12	16.6	92	6	3 11	15.5	94	7	3 5	12.0	97	8
5 2	16.6	90	6	5 4	15.6	92	7	5 13	11.8	98	9
6 27	16.3	91	8	6 25	15.3	93	8	6 17	11.9	100	8
h. m.	900 M.			h. m.	1100 M.			h. m.	1200 M.		
10 3m	9.3	93	8	10 10m	8.1	90	8	10 14m	7.4	89	9
10 42	8.8	97	7	10 38	7.5	97	8	10 36	6.8	97	8
2 11a	8.6	99	9	2 15a	8.0	89	9	2 16a	7.8	84	9
2 58	9.3	93	8	2 53	8.3	87	9	2 51	7.6	84	9
5 25	9.2	98	9	5 32	7.8	99	10	5 35	7.2	99	11
6 8	9.0	98	9	6 4	7.6	98	10	6 1	7.8	89	10

secured for each 100 m. of ascent up to 1200 m. Results are tabulated. Some are given herewith. On the lightship the Kuznetsov thermohygrograph and the Assmann psychrometer were employed. Precautions taken to secure accuracy are fully described.

E. O. W.

399. *Actinometry during Total Solar Eclipse, April 17, 1912.* **F. Lindholm.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 21. pp. 1-11, 1918.)—Observations were made with two Ångström compensation pyrheliometers, and the record of obscuration of the sun's disc during the progress of the eclipse was obtained by a Steinheil objective of 2.5 m. focal length provided with an enlarging lens, giving a solar image 6 cm. diam. One of the pyrheliometers was used to record the total radiation, and the other to show the blue-violet radiation passing a special screen. Tables are given of the readings taken, and the results are also plotted showing the curves of variation.

C. P. B.

400. *The Relations between the Aperiodic Variations of Pressure and Temperature.* **J. v. Hann.** (Meteorolog. Zeitschr. 30. pp. 528-532, Nov., 1918. Extract.)—The theory formerly in vogue that changes of pressure are due to corresponding changes of temperature in the contrary direction, is shown to be untenable by a consideration of the day-to-day variations of the two elements in different parts of the world, both over the interior of continents and in maritime countries. The greatest day-to-day changes of temperature occur over the interior of large continents, the least at stations situated on the sea. On the other hand, for any particular latitude, the max. day-to-day pressure-changes occur over the oceans, the least over the interior of continents. The diminution of the magnitude of the pressure-changes as

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one passes within a continent is ascribed to the friction of the earth's surface upon the winds forming the circulation within the area of a barometric minimum. [See Abstract No. 1784 (1918).] R. C.

401. Meteorology: A Return to Normal Atmospheric Transparency. H. H. Kimball. (Washington Acad. Sci., Journ. 4. pp. 17-26, Jan. 19, 1914.)—Attention has already been drawn to the widespread decrease in atmospheric transparency which followed the eruption of Katmai volcano (Alaska) in June, 1912 [see Abstract No. 1264, 1918)]. For the purpose of tracing the gradual return to normal transparency the records of solar radiation and polarisation of skylight at Mount Weather and Madison for individual months since June, 1912, are compared with the average value for the month derived from observations prior to the eruption. Curves showing the departure from mean value of these two elements show very similar results, with a decided maximum departure in Aug., 1912, and thereafter a gradual return to normal conditions in Dec., 1918. It is concluded that the main part of the dust thrown up by the eruption had been precipitated from the atmosphere by the end of 1918. The duration of the dust-cloud was thus markedly less than the duration (three years) of that which followed the Krakatoa eruption in 1883. J. S. Di.

402. Vertical Temperature Gradients between Mount Weather, Va., and Valley Stations. A. J. Henry. (Mount Weather Observatory, Bull. 6. pp. 85-87, 1918.)—Since this subject was last discussed [see Abstract No. 997, 1912)] further data have become available. It is found from the means of this longer series of observations that the vertical temperature gradients between the mountain and the three valley stations are least in winter (0.58° , 0.80° , and 0.27° C. per 100 m. to the three stations) and greatest in summer (0.68° , 0.49° , and 0.48° respectively). The minimum gradient between Mount Weather and each of the low-level stations occurs in January. J. S. Di.

403. Universal Thermometer Screen for the Determination of Air Temperature and Humidity, for use at Meteorological Stations. W. Köppen. (Meteorolog. Zeitschr. 30. pp. 474-488, Oct., and pp. 518-528, Nov., 1918.)—The errors of the screens in general use in Europe are described. The Stevenson screen adopted for the British Isles provides the best exposure of these if the ventilated Assmann psychrometer be taken as standard. On days and nights with strong radiation the Stevenson screen gives values of maximum and minimum temperature which are slightly too high and too low respectively. The Glaisher stand and French screen, which merely protect the instruments against direct solar radiation, are less satisfactory in comparison with that standard. In this type of screen the maxima and minima are higher and lower respectively than corresponding readings in a Stevenson screen on days of strong radiation. The Wild screen, which is very large but entirely covered in, gives values of maxima and minima which are both too high in comparison with the Assmann standard. The exposure on the north wall of a house, much used in Germany, is not good, the temperature maxima obtained there being too low and the minima too high. All the exposures become more satisfactory as the velocity of the wind increases from a calm.

The points to be considered when designing a screen for the determination of the true air temperature are :—(1) The screen must protect the thermo-

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meters from damage, rain, and radiation, but must allow a free passage of air through it. (2) The longer the path of the air through parts of the screen which are heated by radiation, the more likely is the temperature of the air to be affected as it passes through. (8) The greater the capacity for heat of a body, the more will variations in the temperature of any impinging air be diminished and retarded. It follows (1) that the material of a screen should possess a small coefficient of emission and absorption, and that it should be a bad conductor of heat. (2) The dimensions of the sides of the screen through which most of the air passes should be as small as possible, and the velocity of the air through the screen should be as great as possible. (8) The mass and heat capacity of all parts which can influence the temperature of the air should be made as small as possible.

The Stevenson screen fulfils these conditions fairly well. The author puts forward the following modifications of it which are intended to make its use applicable to all countries with satisfactory results. At the same time the modifications permit of the installation in the screen of a thermo-hygrograph instead of the maximum and minimum thermometers if desired, the complete equipment in that case being the thermo-hygrograph and dry- and wet-bulb thermometers. The three lower louvres of the east side of the screen are removed parallel to themselves to a position nearer the west side, and a second perforated floor is introduced above them so that the screen becomes divided into two parts: a large upper portion which contains the clock drum and pens of the thermo-hygrograph and the stems of the thermometers, and a small lower portion on the west side which contains all the parts of the instruments which require most protection from radiation, viz., the bimetallic thermometer, the hair of the hygrograph, and the bulbs of the thermometers. In addition to these changes a straw roof to the screen is recommended; also a straw shelter to shade the whole of the screen from direct solar radiation. This shelter varies in shape and position according to the latitude of the station. Experiments are being made in Switzerland to test the capacity of this type of screen to withstand the intense solar radiation there experienced. It will be observed that the lower portion, *i.e.* the screen proper, is of very small dimensions, while allowing of the free ingress and egress of the air. R. C.

404. *Solar Radiation*. F. W. Very. (Amer. Journ. Sci. 86, pp. 600-685, Dec., 1918.)—There are two methods of measuring solar radiation. The first, the actinometric, is the most direct and has been most generally employed; but the author prefers the second method, the spectro-bolometric, as giving rise to fewer uncertainties in the determination of the solar constant. This method traces the distribution of energy in the solar spectrum, determines the wave-length of the maximum point in the spectral energy curve, and infers by theory the temperature and radiating power of the solar surface, from which the intensity of the radiation at the earth's distance is at once known. Taking the most reliable figures available by this method, it is concluded that the effective temperature of the sun is about 6800° abs., from which the value 8.5 gm.-cals. per cm.² per min. for the solar constant is deduced. The very much lower values which have been obtained by the actinometric method are ascribed to inadequate corrections for the absorption due to water-vapour in the air. There has been difficulty in finding any suitable formula to connect the loss of solar radiation in passing through the atmosphere with the vapour pressure at the surface. The author puts forward a table of corrections which lead to consistent values of the solar

constant under widely different degrees of vapour pressure at the surface, and he concludes that these tables may be regarded as satisfactory for obtaining a mean corrected value from many measurements. Individual determinations must always be liable to error, since the surface vapour pressure cannot be a reliable guide to the total vapour contents of the atmosphere. When these suggested corrections are applied to existing actinometric measurements a value of the solar constant in excess of 8 gm.-cals. is obtained. The final conclusion is reached that the value of the solar constant is certainly not less than 8 and may be as large as 4 gm.-cals. per cm.² per min. A large fraction of this radiation is absorbed in the upper layers of the atmosphere, so that not more than 2 gm.-cals. reach the tops of the highest mountains. J. S. DI.

405. *Conduction of Heat in "Pseudo-isotropic" Earth.* A. v. ANDERKÓ. (Meteorolog. Zeitschr. 80, pp. 580-589, Dec., 1918.)—By a "pseudo-isotropic" earth the author means earth which changes either periodically or at irregular intervals in its coefficient of conductivity, its density, and its specific heat, owing to admixture with varying amounts of water, which originates either as rain or as underground water. The paper is a mathematical discussion of the temperature conditions in such an earth, and it is illustrated by examples drawn from the observations of earth-temperature made in Tiflis and Pawlowsk. R. C.

406. *The Barometric Gradient as a Secondary Cause of Earthquakes.* K. Hasegawa. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 181-185, Nov., 1918.)—The paper contains an investigation of the possible connection between a local earthquake and the atmospheric condition prevailing just before the occurrence of the shock. The author has selected fifty local earthquakes which occurred at Gihu from 1904 to 1906. Comparing the atmospheric pressure at Gihu with the pressures at a few surrounding stations a few hours before each earthquake, the author finds that the current pressure at Gihu was neither higher nor lower in all the cases than at these stations. He next examined whether an abrupt change of atmospheric pressure may be a secondary cause of local earthquakes, but could not draw any definite conclusion owing to the scantiness of data available. Finally he investigated the baric gradient at Gihu at a time about 80 minutes before the occurrence of each local earthquake, using T. Okada's graphical method; two sets of tables are given. The conclusion is drawn that it is highly probable the gradient of the atmospheric pressure prevailing shortly before the occurrence of a local earthquake may be a secondary cause of the same. H. H. HO.

407. *Absorption and Polarisation of Sunlight.* A. Boutaric. (Acad. Roy. de Belgique, Bull. No. 7, 1918. Le Radium, 11. pp. 15-26, Jan., 1914.)—Where light is transmitted through a liquid in which a fine precipitate has just been formed, the absorption due to the liquid increases with the time, while the proportion of polarised light in the scattered light at right angles to the incident beam decreases, both changes being due to the increase in size of the precipitated particles. The similar problem of sunlight passing through the atmosphere has been investigated experimentally. The intensity of solar radiation was measured with an Ångström pyrheliometer, and the proportion of polarised light in the sky by means of a Cornu photopolarimeter. The measurements show that for the greater part of the radiation received from the sun the absorption due to the atmosphere is closely connected with the proportion of polarised light in the general light from the sky. C. P. B.

408. *Sun-spot Periodicity as Fourier Series.* H. H. Turner. (Roy. Astronom. Soc., M.N. 78. pp. 714-782, Supplementary No., 1918.)—Preliminary trials in the calculation of the Fourier sequence of exact submultiples of 156 years, which is approximately the length of the period for which we have available Wolf's sun-spot numbers. [Abstract No. 89 (1914).] Further study suggests that the method may be preferable to the periodogram method, as from the sequence thus determined the coefficients for any other intermediate periods can be quickly and simply inferred. C. P. B.

409. *Position of Sun's Axis.* F. W. Dyson and E. W. Maunder. (Roy. Astronom. Soc., M.N. 78. pp. 678-687, 1918.)—From a detailed discussion of the photographs of the sun from 1874-1912, giving positions of sun-spots for measurements made at Greenwich, it is found that small corrections are needed to be applied to Carrington's elements, giving the true positions of the solar equator, for the epoch 1850.0 as $I = 7^{\circ} 10.5'$; $N = 78^{\circ} 46.8'$. The discordances found between the corrections deduced for short periods, such as a single year, or from spot-groups in restricted zones, are due to the large proper motions of individual groups. A slight tendency is suggested for high-latitude spots in either hemisphere to move away from the equator, but for those in lower latitudes to move towards it. C. P. B.

410. *Sun's Axis of Rotation.* A. A. Buss. (Observatory, No. 468, pp. 477-478, Dec., 1918.)—It is suggested that there are only two zones of spot-drift, one on either side of the sun's *physical* equator of a particular period, the drift in both these zones being directed towards the respective pole. It has usually been stated that spots between 20° N. and 20° S. latitude appear to approach the equator, while those outside these limits show a pronounced tendency to move poleward. It is possible, therefore, that a distinction should be recognised between the sun's *physical* and its *geographical* equator. C. P. B.

411. *Equatorial Acceleration of the Sun.* Fessenkoff. (Comptes Rendus, 157. pp. 884-887, Nov. 10, 1918.)—Assuming the presence of a heterogeneous fluid mass, subject to gravitational attraction of its parts, with a uniform rotation, an analysis is given of the variations of surface-level following on a certain supposed distribution of internal densities. From this is deduced a formula giving the angular velocity of rotation, and the computed values are compared with those actually observed. C. P. B.

412. *Radial Motion in Sun-spots.* C. E. St. John. (Astrophys. Journ. 88. pp. 841-891, Nov., 1918. Contribution from the Mt. Wilson Solar Observatory, No. 74.)—In a previous paper [Abstract No. 194 (1914)] the displacements at the peripheral edges of the spot penumbrae were given for some 500 solar lines. The present paper continues and amplifies the discussion, with tables showing the various velocities found for lines of varying origin and intensity. These differing displacements shown by the Fraunhofer lines at the edges of penumbrae of eccentrically situated sun-spots seem to find their simplest explanation in movements of the solar vapours tangential to the solar surface with velocities varying with the elevation. The H_2 and K_2 lines of calcium are of the highest level, followed by the H_α line of hydrogen, and in general it may be said that the heavy and rare elements occur in detectable amounts only in the lower portions of the solar atmosphere. The enhanced lines show smaller radial displacements than unenhanced lines of
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the same solar intensities, and would appear to originate in higher levels in and near sun-spots. The results also link up satisfactorily with the observations of rotation and magnetic separation of lines. C. P. B.

413. *Gravitational Instability and the Nebular Hypothesis.* J. H. Jeans. (Roy. Soc., Phil. Trans. 218. pp. 457-485, Feb. 2, 1914.)—This is an inquiry how far researches, e.g. of Maclaurin, Jacobi, Poincaré, and Darwin, into rotating matter assumed homogeneous and incompressible, may be expected to give approximations to the behaviour of the actual matter of astronomical systems. *A priori*, wide differences would be expected. But the complexity of the general stability problem for a sphere of actual matter is greatly reduced by the considerations that—Every change in elastic energy involves an increase in potential energy, while every change in gravitational energy involves a decrease in potential energy, so that the stability condition is that for every possible displacement the former shall exceed the latter. It appears to be a general law that, apart from artificially constructed systems, the elastic and gravitational energies march together, so that the stability condition is fulfilled. Thus every natural spherical system is found to be stable. Inquiring how far rotation can disturb this stability, the ideal incompressible mass is found to supply a surprisingly good model of the actual systems. The results so far achieved make it probable that up to the first appearance of instability the actual mass will behave almost exactly as the model, passing, as rotation increases, through a series of flattened configurations very similar to the Maclaurin spheroids, and from them to the Jacobean ellipsoids. A vibration will be stable if the gain in elastic energy exceed the loss in gravitational energy. Now the latter is practically determined by the vibrations of greatest wave-length, while the former is affected to nearly the same extent by all vibrations. Instability can therefore enter only through disturbances of greatest possible wave-length, and these are identical for compressible and incompressible spheres. G. W. DE T.

414. *Albedo of the Earth.* F. W. Very. (Astronom. Nachr. No. 4696. Nature, 92, p. 496, Dec. 25, 1918. Abstract.)—An attempt is made to determine the albedo of the earth from visual observations of the earth-shine on the moon, in comparison with light from similar sun-illuminated areas on the moon's surface; the resulting value is $A_e = 0.09$. C. P. B.

415. *Brightness of the Reflected Rays from Brooks's Comet (1911c).* S. V. Orlov. (Acad. Sci. St. Pétersbourg, Bull. 2. pp. 151-154, Feb. 1, 1914. In Russian.)—The author gives an account of his attempt to calculate the brightness of the reflected solar rays (evidenced by the continuous spectrum), as distinct from that of the nucleus of Brooks's comet itself. For purposes of this investigation were taken the photometric observations of Bemporad on the brightness of the nucleus, secured by aid of a Toepfer wedge photometer used with a Cooke equatorial of 15 cm. aperture and 228 cm. focal length, with magnifying power of 75. The desired magnitudes of the mean brightness of the reflected rays, of those originating in the nucleus, and the variable brightness were determined by the equations derived from the method of least squares. The brilliancy of the comet, as in the case of that of Encke-Backlund was notably greater as it approached perihelion than after. A curve is given exhibiting the data obtained by the author, based on a star of 9.88 mag. as unit; for comparison a curve is also given showing the mean indication of the brightness of the nucleus according to Bemporad. The two curves

show good agreement; they relate to the period Aug. 10 to Oct. 29. The brightness of the reflected rays from the nucleus of Brooks's comet may be taken as approximating to that of its own brightness, and nearly equal to 8.8 mag. E. O. W.

416. *Terrestrial Refraction.* C. V. L. Charlier. (Comptes Rendus, 157. pp. 881-884, Nov. 10, 1918.)—Formulæ are developed connecting the differential refraction with different heights and the physical constitution of the atmosphere. C. P. B.

417. *Zodiacal Matter and Solar Constant.* E. Belot. (Comptes Rendus, 157. pp. 757-760, Nov. 8, 1918.)—An exponential law for the planetary distances is considered to give better interpretation of the natural facts than the older Bode's law, and assigns theoretical distances to five zones of asteroids which would appear to account for many of the facts of observation very closely. One of these rings is found to correspond to an elongation of 35° for the brightest part of the zodiacal light, and this is very near the value observed by Newcomb at the summit of the Rothhorn. An interesting computation is given in illustration of the possible effect of such a zone on the absorption of the solar radiation, and the variations predicted appear to have some relation to the variations found by Abbot, Fowle, and Aldrich from observations of the solar constant in California and Algeria. C. P. B.

418. *Magnifying Powers for Double-star Observers.* T. Lewis. (Observatory, No. 467, pp. 428-428, Nov., 1918.)—Diffraction effects begin to deteriorate the definition in a telescopic combination when the magnifying power is greater than the number of mm. in the diam. of the object-glass (Whittaker "Optics"). In the case of resolution of two stars in close proximity, the fact of a star image being a small disc, and not a point, becomes of considerable importance. A series of six determining factors are discussed in their bearing on the practical observation of double-star separations. After this tables are given showing the examination of the instrumental constants of well-known double-star observers, using instruments with objectives varying from 3.8 to 86.0 in. in diam. From this it appears that the best practical magnification may be calculated from the formula $M = 140\sqrt{A}$, where M = magnifying power, and A is the diam. of the objective in inches. C. P. B.

419. *Stellar Spectra with Bright Hydrogen Lines.* P. W. Merrill. (Lick Observatory, Bull. No. 287. Nature, 92. p. 854, Nov. 20, 1918. Abstract.)—A photographic survey has been made at the Lick Observatory of all stars of Class B whose spectra show bright hydrogen lines, and which are north of declination -40° . Tests were made on two stars for evidence of polarisation in the H_β line, with negative results. C. P. B.

420. *Photographic Spectra of Class A Stars.* E. P. Waterman. (Lick Observatory, Bull. No. 248. Nature, 92. p. 854, Nov. 20, 1918. Abstract.)—From a study of a number of the brighter Class A stars it is agreed that Miss Cannon's proposal to rearrange their classification is advisable. The metal lines found present are the enhanced or special spark-lines, agreeing in wave-length and intensity with the lines of the solar chromosphere. C. P. B.

421. *Later Spectrum of Nova Geminorum No. 2.* W. S. Adams and J. B. Lasby. (Roy. Astronom. Soc., M.N. 78. pp. 742-744, 1918.)—The paper deals principally with the sequence of variations of intensity of the line $\lambda 4686$. The structure of the band at this wave-length is precisely like that of the hydrogen and nebular bands, consisting of two equal maxima at the edges of the band separated by a broad faint absorption band which lies symmetrically on it. Allowing for the variations in density of the negatives, the widths and the positions of the centres of both the hydrogen and the nebular bands have remained remarkably constant throughout the entire series of observations, extending from 1912 May 10 to 1918 April 27. C. P. B.

422. *Orbits of λ Tauri and ϕ Persei.* F. Schlesinger, F. C. Jordan, and A. H. Pfund. (Allegheny Observatory, 8. Nos. 4, 5, 6. Nature, 92. p. 460, Dec. 18, 1918. Abstract.)—Notes of spectroscopic observations of eclipsing variables, with details of the velocity curves. C. P. B.

423. *Statistics of Nebulae and Clusters.* C. V. L. Charlier. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. 15. pp. 1-85, 1918.)—The investigation has been carried out at the Lund Observatory, with the object of determining the distribution of the nebulous stars in space. Information regarding the co-ordinates, brightness, size and form of the various objects has been collected, and the various tabulations are discussed in detail; illustrations are also given showing graphically the distribution with regard to the Milky Way. C. P. B.

424. *New Nebulae and Variable Stars.* C. R. D'Esterre. (Astronom. Nachr. No. 4697. Nature, 92. pp. 484-485, Dec. 11, 1918. Abstract.)—Observations of an abnormal object exhibiting a long period of brightness and rapid decline which may be a new variable or nova. Also of several new nebulae in the neighbourhood of I Cassiopeiæ. C. P. B.

425. *Parallax of Binary Systems.* S. G. Cederstrand. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 84. pp. 1-24, 1918.)—The published observations of the positions of the binary systems Σ_4 and Σ_2 are discussed for the investigation of their parallax. C. P. B.

426. *Radial Velocity of Andromeda Nebula.* V. M. Slipher. (Lowell Observatory, Bull. No. 58. Nature, 92. p. 411, Dec. 4, 1918. Abstract.)—From a series of spectrograms obtained with exposures of from 6h. 50m. during Sept., Nov., and Dec., 1912, the mean radial velocity of the Andromeda nebula is given as -800 km. per sec. C. P. B.

LIGHT.

427. Total-reflection Prism. **K. Pritschow.** (*Zeitschr. Instrumentenk., Beib.* 21. pp. 221-227, Nov. 1, 1918.)—Describes, with diagrams, a special form of total-reflection prism ("Dachprisma"). Used with a simple eyepiece and objective we have a telescope similar in action to a terrestrial telescope, giving no inversion of the object, but simply changing the line of view from (say) the vertical to the horizontal. Such an instrument could be used with advantage in observing airships, etc. Another form may be used with an ordinary total-reflection prism for direct vision, while others change the view line through angles depending on the angle of the prism. For diagrams and details see original paper. A. W.

428. Process for Stereoscopic Kinematography. **J. Sahuika.** (*Elektrotechnik u. Maschinenbau*, 82. pp. 87-88, Jan. 11, 1914.)—Two films are exposed in a stereoscopic camera. Pictures from these films alternately, are thrown on to a single screen, the projectors being so adjusted that the successive pictures occupy exactly the same position on the screen. Each spectator views the pictures through a binocular with a revolving disc in front of it. This disc is driven by a motor running in synchronism with the film-driving motor and has slots in it which are arranged to leave each eye unobstructed at the instant its own picture is on the screen.

F. T. C.

429. Reflection of Light at the Confines of a Diffusing Medium. **Rayleigh.** (*Nature*, 92. p. 450, Dec. 18, 1918.)—An experimental and mathematical treatment of the problem as suggested by the beautifully graded illumination of a paraffin candle, extending downwards from the flame to a distance of several inches. The effect is seen at its best when there is but one candle in an otherwise dark room, and when the eye is protected from the direct light of the flame. And it may be noticed when a candle is broken across, so that the two portions are held together merely by the wick, that the part below the fracture is much darker than it would otherwise be, and the part above brighter, the contrast between the two being very marked. This effect is naturally attributed to reflection, but it does not at first appear that the cause is adequate, seeing that at perpendicular incidence the reflection at the common surface of wax and air is only about 4 per cent. A little consideration shows that the efficacy of the reflection depends on the incidence not being limited to the neighbourhood of the perpendicular. The mathematical treatment explains the observed facts of diffusion, by far the greater part being due to total reflection which ensues on oblique incidence in the wax.

E. H. B.

430. Phase-variation of Light Totally Reflected. **S. Rybár.** (*Ann. d. Physik*, 42. 6. pp. 1171-1195, Dec. 23, 1918.)—A review is given of previous work, and it is pointed out that hitherto experimental methods have only given the difference of phase of the incident and reflected rays. The present method gives the absolute phase-variation of the parallel and perpendicular components of the incident ray. The arrangement of apparatus appears to

be suited for the investigation of other questions besides that here dealt with. An elementary theory of the method is presented, which is only valid for the cases with which the present work is concerned—namely, for the parallel and perpendicular components of the totally reflected light. The experimental results have been compared with Fresnel's theory in a detailed quantitative manner, and complete agreement was obtained. A detailed, though only qualitative, investigation was also made whereby the well-known facts of the variation of phase of the light reflected from optically dense media at about 180° were confirmed. A. W.

431. Scattering in the Case of Regular Reflection from a Transparent Grating. C. BARUS. (Nature, 92, pp. 451-452, Dec. 18, 1918.)—A beam of light from a collimator is reflected from the two faces of a plate-glass grating having about 10,000 or more lines to the inch, the ruled surface being towards the source. It is found that relatively more blue light is regularly reflected from the ruled surface than is transmitted, and more reddish light transmitted than is reflected. The phenomenon is strictly regular reflection, i.e. there is a wave-front, for the blue and the yellow slit-images are absolutely sharp in a telescope. This latter feature associates the phenomenon with the recent discovery of Friedrich, Knipping, and Laue relative to the reflection of X-rays from the molecules of crystals. The author gives a theoretical consideration based on the idea that the wave-fronts of regularly reflected and scattered light are superposed. E. M.

432. Non-selective Transmissibility of Radiation through Dry and Moist Air. F. E. FOWLE. (Astrophys. Journ. 88, pp. 392-406, Nov., 1918.)—An account is given of the determination of non-selective absorption of radiation between the wave-lengths 0.84μ and 1.7μ associated with atmospheric aqueous vapour and of the general transmission coefficients for radiation passing through a dry atmosphere. The method consists of the correlation of the atmospheric scattering of solar radiation with the amount of water-vapour present. The transmission coefficient for dry air is then used for the determination of the number of molecules, N_0 , per cm.³ of a gas at 760 mm. pressure and at 0° C. This result gives $N_0 = 25.6 \times 10^{18}$. This mode of analysis shows that, except when selective absorption occurs, the depletion of the beam from the sun as observed in 1910 and 1911 at Mount Wilson, was caused almost wholly by molecular scattering. The same analysis applied to atmospheric aqueous vapour shows that the observed absorption is very much too great to be accounted for by the number of water molecules present; and leads to the idea of the vapour being loaded with something greater than molecules. [See Abstract No. 1981 (1918).] C. P. B.

433. Absorption of Ultra-violet Light by Inorganic Salts. T. RETSCHINSKY. (Ann. d. Physik, 42, 6, pp. 1580-1588, Dec. 23, 1918.)—Absorption-spectrum curves are given for lithium and sodium chlorides, bromides, iodides, and nitrates in the range from 400 to about 200μ . In many cases an actual absorption band (max. absorption) is observed between wave-length 800 and 250μ . In cases where this is absent there is a very marked "step-out" in the curve; thus even the chlorides give absorption-curves which are practically horizontal from 800 to 250μ . The observations are in accord with those of Lübben on the dispersive power of dissolved salts, according to which there are "free-periods" corresponding with wave-length 165μ for chlorides, 186μ for bromides, and 288μ for iodides. T. M. L.

434. Tyndall Phenomenon in Gelatine Solutions. L. Arisz. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 881-886, Oct. 24, 1918.)—The intensity of the Tyndall phenomenon in gelatine solutions kept at constant temperature undergoes gradual increase. This change occurs with the solution as well as with the gel-condition, and sometimes occupies several days, the solution approaching an equilibrium determined by the temperature. The influence of the temperature varies with the concentration of the gelatine solution. With 1 per cent. and 2 per cent. gelatine solutions, the intensity of the phenomenon is not influenced by raising the temperature above about 80°, but below 80° the intensity increases markedly as the temperature is lowered. With more concentrated solutions, the influence of temperature shows itself at higher temperatures.

T. H. P.

435. Refractive Index of Gaseous Mixtures. S. Valentiner and O. Zimmer. (Deutsch. Phys. Gesell., Verh. 15. 24. pp. 1801-1816, Dec. 80, 1918.)—Describes experiments, made by the interference method, on the refractive index of the two mixtures (i) He—Ne—H and (ii) CO₂—H. Various proportions of the constituent gases were used in both cases. The accuracy of the apparatus was tested by some observations on dry air freed from CO₂. Several modifications were introduced into the apparatus particularly to secure an even temperature throughout the gas chambers. Observations were made by varying the pressure of the gas under observation until the null-point of the compensator was nearly reached. The actual "null" pressure was then obtained by interpolation, and the refractive index calculated from the equation $(n_2 - 1) = (n_1 - 1) \cdot p_1 T_2 / p_2 T_1$, where n_1, p_1, T_1 , and n_2, p_2, T_2 are the refractive indices, pressures, and temperatures of the two gases to be compared. The results for the two above mixtures are tabulated and the experimental error is given as $\pm 0.2\%$ for a pure gas and $\pm 0.7\%$ for a mixture. The agreement with the values calculated from the Lorenz-Lorentz formula is, in general, good. In the case of mixture (ii), however, the refractive index is slightly but distinctly smaller than is to be expected from the formula. The refractive index found for pure dry air is 1.0002981 (wave-length 0.578 μ).

J. W. T. W.

436. Constancy of Velocity of Light. W. de Sitter. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 895-896, Nov. 27, 1918.)—In an earlier note [Abstract No. 1418 (1918)] the author pointed out that the existence of spectroscopic doubles whose motion obeys the laws of Kepler, is incompatible with the theory of Ritz, while it may be in agreement with the theory of Lorentz. A calculation is now made of the upper limit assignable to the coefficient of the possible term depending on the source velocity, giving this as < 0.002 , for stars with parallaxes $< 0.05''$.

C. P. B.

437. Tyndall Phenomenon. E. Wilke and H. Handovsky. (Ann. d. Physik, 42. 6. pp. 1145-1158, Dec. 28, 1918.)—An experimental research on the scattering of light shown by Tyndall and mathematically treated by Rayleigh (in 1871). An arrangement is described by which may be measured the intensity of the Tyndall light for different thicknesses of the illuminated layer. It is thus shown that the falling off in the light in the Tyndall layer follows an exponential law. The attenuation exponent is dependent on the ratio of the two intensities, that of the scattered and that of the incident light. This exponent depends also on the chemical properties of the illuminated substance.

E. H. B.

438. Strain in Large Glass Bodies due to their own Weight. E. Zschimmer. (*Zeitschr. Instrumentenk.* 88, pp. 876-878, Dec., 1918.)—An investigation was made of the double refraction resulting from strain due to their own weight in the case of glass discs 27 cm. in diam. and 8 cm. thick. The method of Mach and Fritsch was used to obtain photographs, a number of which are reproduced. A. W.

439. Radiation-pressure. H. L. Callendar. (*Nature*, 92, pp. 450-451, Dec. 18, 1918.)—The theory recently outlined by the author [Abstract No. 286 (1914)] leads to the conclusion that "the total pressure of full radiation should be one-third of the intrinsic energy density, but this could not be true for the partial pressure of each component taken separately." On the gas analogy the vibrations should be adiabatic, in which case $p v = \text{constant}$ would involve the impossibility $(E + p v)/E = (\text{total energy})/(\text{intrinsic energy}) = \text{unity}$. Therefore analogy is false, or, if the vibrations are adiabatic, the ratio may have different values for different frequencies. Since the index $\gamma = (E + p v)/E$, $p = (\gamma - 1)E/v$, as Rayleigh found for monatomic gases [Abstract No. 1248 (1905)]. According to the author's theory, $\gamma - 1$ must be of form T/bv , which is different for different frequencies. This could be tested experimentally thus:—Divide the radiation from a source into two parts of different frequencies: compare total energies and pressures. Then in the author's theory, the part of lower frequency should have the higher pressure in a determinate ratio, while on Maxwell's theory the ratio of pressure to energy should be the same for each part. (*Ibid.* p. 500, Jan. 1, and pp. 629-630, Feb. 5, 1914.)—Replying to correspondence following on the above publication, the untenability of the simple relation—pressure = one-third of energy density always—is shown thus:—Admittedly, total heat in emission, or absorption, of unit volume of radiation = $E/v + p$. This, by Carnot's principle, = $T(dp/dT)$. Whence, if $E/v = 8p$, the fourth-power law for full radiation follows. If true for each separate frequency, constant-frequency radiation should increase with temperature according to fourth-power law. It does not. Therefore either Carnot's principle is inapplicable or E/v does not equal $8p$ for each separate frequency. The author prefers the latter alternative.

The formula $E_\lambda = 8\pi R\lambda^{-4}T/N$, a necessary consequence of electromagnetic equations from which $E/v = 8p$ was first deduced, is so in conflict with experiment, except for long waves and high temperatures, as to suggest something overlooked in application or interpretation of equations.

Nichols and Hull's experimental proof that pressure of a beam of light equals energy-density irrespective of wave-length accords with the author's theory, according to which the mechanical effect they measured should equal $E/v + p$, as deduced from their energy measurements. The suggested measurement of p separately from E/v may, however, prove difficult, or even impracticable. C. G. Darwin (*Ibid.* p. 585, Jan. 22, 1914). G. W. DE T.

440. Pressure of Radiation and Carnot's Principle. Rayleigh. (*Nature*, 92, pp. 527-528, Jan. 8, 1914.)—As is well known, the pressure of radiation, predicted by Maxwell and experimentally confirmed by Lebedew and by Nichols and Hull, plays an important part in the theory of radiation developed by Boltzmann and W. Wien. The existence of the pressure according to electromagnetic theory is easily demonstrated, but it does not appear to be generally remembered that it could have been deduced with some confidence from thermodynamical principles, even earlier than in the time of Maxwell.

Such a deduction was, in fact, made by Bartoli in 1876, and constituted the foundation of Boltzmann's work. Bartoli's method is quite sufficient for his purpose; but, mainly because it employs irreversible operations, it does not lend itself to further developments. The present paper then details the elementary argument on the lines of Carnot, by which it appears that in the absence of a pressure of radiation it would be possible to raise heat from a lower to a higher temperature.

The imaginary apparatus is, as in Boltzmann's theory, a cylinder and piston formed of perfectly reflecting material, within which we may suppose the complete or black radiation to be confined. The cycle of operations is the same as in Carnot's theory, the only difference being that here, in the absence of pressure, there is no question of external work. The sole result of the cycle is that heat is raised from a lower to a higher temperature. Since this is assumed to be impossible, the supposition that the operations can be performed without external work is to be rejected—in other words, the radiation must be regarded as exercising a pressure upon the moving piston. Carnot's principle and the absence of a pressure are incompatible. A further discussion is given in a mathematical form. **H. L. Callendar** [*Ibid.* p. 558, Jan. 15, 1914.] **E. H. B.**

441. Luminous Spherical Waves. P. Sélénýi. (*Comptes Rendus*, 157, pp. 1408-1410, Dec. 22, 1918.)—Non-homogeneous plane waves have been known for some time, especially since the researches of Voigt. They are waves in which the plane containing points of equal phase does not coincide with that of the points of equal amplitude, these planes making a certain angle with one another, the value of the amplitude in the plane of equal phases being given by the function $a_0 e^{-kl/\lambda}$, where a_0 and k are constants, l the distance from a fixed point of the plane of equal phases, and λ is the wavelength. The most interesting example of these waves is produced in the less refractive medium when there is total reflection at the plane surface of separation of two media. In the present paper the author shows that if light coming from a source situated in a less refractive medium passes into a more refractive medium, a part of this light is propagated outside the cone of total reflection in spherical non-homogeneous waves. Plane waves are first considered, and then similar methods are applied to the second case, expressions being obtained for the factor determining the phase and for the amplitude. The existence of these spherical non-homogeneous waves may be shown by the following arrangement:—On the hypotenuse of a total-reflection prism is placed a drop of a solution of fluorescein; light is allowed to fall on this drop, which becomes fluorescent, and then, the eyes being accommodated to infinity, the surface of the cone of total reflection is observed. It appears then that the luminous intensity is not zero outside the cone, but on the contrary is perceptible to the eye. It results from this that the luminous centres, situated in proximity to the surface of the glass, send some light into the region of space outside the cone, and they send more the nearer they are to the surface. A similar problem arises when the luminous source is a Hertz double pole; it is necessary then to determine the laws of reflection and refraction of the waves which are emitted. This, with other analogous optical phenomena, will be considered in a subsequent paper. **A. W.**

442. Photographic Spectrophotometry. Colour Screens. J. Baillaud. (*Le Radium*, 10, pp. 402-406, Dec., 1918.)—With a luminous source, a photographic plate, and a spectrograph such that the spectrum of the source photographed
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on the plate presents the same degree of blackening for all radiations, the test of the absorption bands of a screen would be very simple: to interpose the screen between the source and the spectrograph and to examine upon the photograph the degree to which the blackening is diminished for certain radiations, would be all that was necessary. Unfortunately, even the best panchromatic plates have not a constant sensitivity for all radiations, and the distribution of energy in the spectrum of known sources is not uniform. The bands produced by the screen thus mingle with those caused by irregularity in the relative actinism of the plate and of the source, and, hence, their determination is by no means accurate. With the spectrophotometer here described these difficulties disappear. The absorption curve is traced by the apparatus itself in a quantitative as well as a qualitative manner. By its use it is possible to obtain to the tenth about, without measurements, the coefficients of absorption of colouring matter for different radiations.

A. E. G.

443. *Influence of Dampness of the Air upon the Constants of the Reichenbach Telemeter.* H. Samel. (Zeitschr. f. Vermessungswesen, 42. p. 858, 1918. Zeitschr. Instrumentenk. 88. pp. 879-880, Dec., 1918. Abstract.)—With the object of testing whether changes of moisture in the atmosphere could affect the tension of the spider-threads sufficiently to cause appreciable errors in practice, experiments were made upon a number of tachymeter telescopes from the geodetic collection of Poppelsdorf Academy. Observations were made firstly in air dried by the use of CaCl_2 , and secondly in air damped by leaving rolls of moist blotting-paper for a considerable time in the vicinity of the instrument. In the second case, indeed, drops of moisture actually hung upon the threads. With one or two trifling exceptions, the differences of the two sets of measures lay within the limits of the errors of observation. Hence the conclusion is drawn that atmospheric changes of moisture do not alter the tension of well-mounted spider threads sufficiently to affect the principal constants.

A. E.

444. *Colouring Material of "Ultra-violet" Flowers.* G. Michaud and J. F. Tristan. (Archives des Sciences, 87. pp. 47-49, Jan. 15, 1914.)—The authors have photographed 90 flowers of all colours through a Foucault screen, which only allowed light to pass through it of wave-length between 8160 and 8260 Å. Each photograph was repeated with an ordinary objective. It was thus found that the very strong absorption of ultra-violet light observed by Wood for some white flowers is a general phenomenon for all flowers that are not yellow. The white corollas, as well as the violet, blue, or red, which were examined, without a single exception all absorb ultra-violet light very strongly, and are of almost a uniform blackness in photographs taken with the Foucault screen. Yellow flowers can be divided sharply into two classes. The first, which includes most with yellow corollas, follow the general rule and give black images in ultra-violet light. The second class, on the other hand, reflect almost totally the ultra-violet light used, and appear white when photographed. Ten of the latter class have been observed up to the present, and the authors propose to call these "ultra-violet" flowers. Photographs of some of these are reproduced. The yellow colouring material of the male flowers of *cucurbita pepo* was extracted by means of boiling alcohol, and on cooling the colouring material separated out. After filtration the material was found to dissolve very easily in benzol or ether. An attempt was made to photograph a layer of the material deposited on a sheet of paper by evaporation of the benzol solution, but the colour had disappeared in less

than 45 minutes. Red and orange-yellow glass was found to hinder the decomposition of the material when exposed to the sun's rays. A. W.

445. *Quantum Theory*. M. Wolfke. (Deutsch. Phys. Gesell., Verh. 15 21. pp. 1128-1129, Nov. 15; 15. 22. pp. 1215-1218, Nov. 30, 1918, and 16. 1. pp. 4-6, Jan. 15, 1914.)—A discussion of the quantum theory on the basis of the supposition that not only in emission and in absorption, but also in free space, luminous energy has a discontinuous character. [See Abstract No. 1456 (1910).] E. H. B.

446. *A Case of Abnormal Trichromatic Colour Vision due to a Shift in the Spectrum of the Green-sensation Curve*. W. de W. Abney and W. Watson. (Roy. Soc., Proc. Ser. A. 89. pp. 282-245, Sept. 22, 1918.)

447. *Theory of the Cornu Photopolarimeter*. G. Dimmer. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 918-932, May, 1918.)

448. *On the Bravais-Zakrzewski Elliptic Analyser*. E. Perucca. (N. Cimento, 6. Ser. 6. pp. 179-198, Sept., 1918.)—Discusses the applications of the analyser and also certain errors. L. H. W.

449. *Sulphides in the Infra-red*. I. B. Crandall. (Phys. Rev. 2. Ser. 2. pp. 848-862, Nov., 1918.)—The author has determined the percentage of infra-red radiation reflected from and transmitted by several specimens of molybdenite, stibnite, and sphalerite, using a balanced method instead of a deflection method with the bolometer. He has calculated the extinction coefficients, and for molybdenite and stibnite also the refractive indices and conductivities. J. M.

450. *Absorption of Ultra-violet Light by Bromine Vapour*. G. Ribaud. (Comptes Rendus, 157. pp. 1065-1068, Dec. 1, 1918.)—The electromagnetic theory of absorption gives for the values of the index of extinction χ the formula $\chi = gg'\lambda^2/2[(\lambda^2 - \lambda_m^2)^2 + g'^2\lambda^2]$. In the case of gases a kinetic theory of absorption developed by Lorentz, then by Bloch, gives for the damping coefficient g' the relation $g' = \lambda_m^3/\pi v t$, t denoting the duration of the mean free path of the gas molecules and v the velocity of light. Lorentz and Königsberger on the one hand, and Bloch on the other, in their attempts at verification, have come to different conclusions. The present paper describes quantitative measurements of the absorption by bromine vapour in the ultra-violet. Bromine vapour has a spectrum of absorption bands easily resolvable into fine lines, extending from $\lambda 5000$ to the extreme red, and also a continuous region of absorption between about $\lambda 5200$ and $\lambda 8400$. The present measurements were made in the latter region. A photographic method of determining the ratio of incident (I_0) and emergent (I) intensities is described. Hence χ is found from $I/I_0 = e^{-2\chi d/\lambda}$, where d is the thickness of gas traversed. Measurements in Br-vapour alone, made at a pressure of 66 mm., give $\lambda_m = 4200$ and $\chi_m = 9.1 \times 10^{-4}$; hence g' can be calculated from the relation $\chi/\chi_m = g'^2\lambda^2/\{\lambda_m[(\lambda^2 - \lambda_m^2)^2 + g'^2\lambda^2]\}$. g' varies considerably along the absorption curve; and the numbers thus found give for t values of the order of 10^{-15} , which, of course, do not agree with the kinetic theory. A second series of measurements made at pressures of from 1 to 15 cm. has shown that for each value of λ , χ is proportional to the pressure, and that, in consequence g' is constant when the pressure of the vapour itself varies. Dufour has

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pointed out that, for the fine absorption lines of Br, g' increases very rapidly if to the vapour is added non-absorbing gas at high pressure. Measurements made with CO₂ at 56 atmos. and with oxygen at 115 atmos. have shown that in the case of the large absorption band g' is not modified. There is simply a diminution of $1/20$ in the value of χ_m , which can easily be explained on the electromagnetic theory. Hence the kinetic theory of absorption is at fault when large bands are in question, though for fine lines it appears to account for the observed facts.

A. W.

461. Investigation of Arc Light with Spectroheliograph. O. Oldenberg. (Zeitschr. wiss. Phot. 18, pp. 188-172, Dec., 1918.)—An apparatus was constructed on the principle of the spectroheliograph, which allowed monochromatic images of an arc light to be obtained. The apparatus was used to investigate the steady-current arc light. Consideration of the Na lines gave the following results:—The principal series and the second subordinate series are emitted principally by the outer portion of the arc flame, the first subordinate series by the inner portion. The fact that the principal series and the second subordinate series are found together throws a new light on the relation between the two already known from the formulæ for spectral series and from observations of the Zeeman-effect. Lines of Al, Mg, Ca, Li, Hg, Cu, Fe, Ba, Si were also investigated. In the investigation of bands two types of image were observed. In the first type, which are furnished by all the carbon and cyanogen bands, the core of the arc light is uniformly bright, while at the edges the brightness gradually diminishes. An altogether different type is given by other bands; in this the edges of the arc are decidedly brighter than the core. Both types show characteristic differences from the arc images furnished by lines. Thus the monochromatic image of the arc may be used as a criterion to determine whether the emission is that of a line or band. The spectrum of the arc-light core was also investigated through a narrow cylindrical hole down the centre of the positive carbon, so that the spectrum of the outer sheath was eliminated. It was found when the conditions are so chosen that the bands of the first type (carbon and cyanogen) appear much brighter in the core than in the outer sheath, that all metal lines, as well as bands of the second type, are, on the other hand, much darker in the core than in the outer sheath.

A. W.

462. Arc and Spark Lines with the Tube-arc. A. S. King. (Astrophys. Journ. 88, pp. 815-840, Nov., 1918. Contribution from the Mt. Wilson Observatory, No. 78.)—Experiments have been continued with the tube-arc [see Abstract No. 1655 (1918)] in which a graphite tube in an electric furnace is arranged to break down at a certain section, thereby forming an arc surrounded by vapour at a very high temperature. Under these conditions it is found that lines specially characteristic of the spark spectrum are obtained. Photographs are reproduced showing the variations of spectrum in different parts of the tube, and the different behaviour of certain elements under similar conditions. Tests are also described in connection with the ionisation of the vapour, and on its conductivity compared to that of the tube material. The results of these indicate that the effects may be largely due to the impact of electrons emitted by the highly heated carbon, the resultant effect of these impacts becoming stronger near the centre of the tube.

C. P. B.

463. Reflection Spectra of Praseodymium Compounds. P. Joye. (Archives des Sciences, 86, pp. 481-488, Nov., 1918.)—Investigations similar to those

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previously made on neodymium salts [see Abstract No. 1951 (1918)] have been carried out with praseodymium oxide, hydroxide, chloride, sulphide, sulphate, nitrate (+ 6H₂O) and oxalate (+ 10H₂O). The reflection spectra are characterised by lines or groups of lines for values of λ between 5000 and 4400 Å., and between 5900 and 5700 Å. The loss of water in passing from the hydroxide to the oxide displaces the spectrum towards the red, and the spectra of the sulphide and chloride are also extended in the direction of the red. With compounds containing an acid radical, the whole of the spectrum is displaced towards the violet. As with neodymium salts, so also with those of praseodymium, the function of the compound plays a more important part in the reflection spectrum than does the metal itself. T. H. P.

454. *Quantitative Study of Absorption Spectra by the Radiomicrometer.* J. S. Guy and H. C. Jones. (Amer. Chem. Journ. 50. pp. 257-308, Nov., 1918.)—In general, the more concentrated the solution of a salt the less the transparency and the broader the absorption band. Aqueous solutions of hydrated salts are often more transparent than pure water; this is attributed to the effect of the dissolved substance on the absorption spectra of water; the combined water seems to have less power to absorb light than free or uncombined water. T. M. L.

455. *Energy-emission from the Atom in Spectral Lines.* H. Zahn. (Deutsch. Phys. Gesell., Verh. 15. 22. pp. 1208-1214, Nov. 30, 1918.)—Wiedemann has calculated the energy emitted per sec. in the D-line region by a sodium atom in a Bunsen flame fed with salt. He found that 1 gm. of Na under such conditions would emit 8210 gm.-cals. per sec. Taking the weight of the H atom as 1.68×10^{-24} gm., the Na atom in the flame would then emit 5.06×10^{-12} erg per sec. Calculations made now by the author give very different results to those of Wiedemann. He finds that each atom gives out 7.01×10^{-9} erg per sec., corresponding to the emission by 1 gm. of Na of 4.47×10^6 gm.-cals. per sec.—values which are roughly 1000 times Wiedemann's values. A. W.

456. *Quantum Theory and Infra-red Absorption Spectrum of Water-vapour.* A. Eucken. (Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1159-1162, Nov. 15, 1918.)—On the old form of the quantum hypothesis the following expression was derived for the frequency of a molecule: $\nu = nh/(2\pi^2 J)$, in which J is its moment of inertia and n is an integer. This equation was applied by N. Bjerrum in 1912 to the data then available for the infra-red absorption spectrum of water-vapour. Since then further work has been done by H. Rubens and E. v. Bahr, and the present author now compares this equation with the present more extended experimental knowledge. The agreement is satisfactory and affords unequivocal evidence for a *discontinuous distribution of energy* and against the newer conception of Planck as to the energy being continuous and only the number of molecules in a specified energy region changing discontinuously. [See Abstract No. 1178 (1911).] E. H. B.

457. *Series of Lines in the Spectrum of Neon.* R. Rossi. (Phil. Mag. 26. pp. 981-984, Dec., 1918.)—Runge and Paschen found that the line spectrum of helium can be grouped into six series, viz., two sets of a principal with its two subordinate series. Watson [Abstract No. 1127 (1911)] failed to find any series in the Ne spectrum, though he found several groups of lines repeating themselves with constant frequency-difference. The present author has found three series of lines in the Ne spectrum: two series of doublets with VOL. XVII.—A.—1914.

constant frequency-difference and common convergence frequency in the visible spectrum, and one series of single lines in the ultra-violet. These series lines are rather weak compared to the lines forming the constant frequency-difference groups, which probably accounts for their being overlooked by Watson. In the tables given the wave-lengths are from Watson's paper [see Abstract No. 1794 (1908)], and, since the lines in series are not numerous, Rydberg's formula was adopted since Kayser's and Hicks' modifications of Ritz's formulæ, although giving better agreement between calculated and observed values, have the disadvantage of requiring one more constant. The two series with a common limit at $\lambda 4119.8$ resemble two subordinate series, but all efforts to find the principal, which might be expected to accompany them, have so far failed. They appear not to correspond with any of the helium subordinate series, for although nearer to the red end of the spectrum the approximate relation between the separation of doublets and the square of the atomic weights does not hold.

H. H. Ho.

458. Origin of Series Spectra. A. W. Conway. (Phil. Mag. 26. pp. 1010-1017, Dec., 1918.)—An attempt is here made to picture a model of an atom based on the classical electrodynamics, which will illustrate some of the properties of spectral series. The principal difficulties in explaining a frequency formula of the type $\nu = A - B/(n + \mu)^2$, where $n = 1, 2, 8 \dots$, are three: (i) the formula gives the frequency and not the square of the frequency; (ii) no elastic or electrical system has a frequency equation of this type, the frequency increases as n increases and becomes infinite with n ; (iii) the amount of radiation given out must obey Planck's law. As regards (i), as pointed out by Rayleigh, the difficulty can be overcome by making the frequency depend on the magnetic force; and as to (ii) this paper is intended to point out a mode of connection between the vibrations of elastic bodies and the above law. The question of energy radiated according to Planck's law is dealt with in the last section, where it is shown that the kinetic energy radiated is homogeneous and of amount $h\nu$, where h is a constant having the value 6.8×10^{-27} (Planck's constant being 6.5×10^{-27}). The atom considered is a "Thomson" atom rotating with a constant angular velocity. It is shown that all single negative electrons having circular orbits in such atoms have a constant angular momentum h/π . If the atom is supposed capable of executing elastic vibrations, reasons are given for supposing that the innermost nodal sphere in any mode will capture the electron. A frequency formula of the type $\nu = A - B/(n + \mu)^2$ is arrived at, A depending on the external structure of the atom, B being the same for all atoms, and μ depending on the nature of the surface conditions for the elastic waves. The simplest form of atom—the sphere—and the simplest mode of vibration—the radial—are considered. It is possible that more complex conditions will give better results.

A. W.

459. Influence of the Size of the Particles on the Electro- and Magneto-optic Properties of a Liquid Mixture. A. Cotton, H. Mouton, and P. Drapier. (Comptes Rendus, 157. pp. 1519-1522, Dec. 29, 1918.)—In a previous paper [see Abstract No. 215 (1914)] the authors have dealt with the optic properties of a liquid mixture submitted to the simultaneous action of a magnetic and an electric field. In a theoretical discussion of the subject [Le Radium, 10. p. 152, May, 1918] Pockels concluded that the method the authors proposed to use ought to succeed in the case of liquid mixtures containing relatively large particles, but that the results should be less and less sharp as the

particles become smaller, and that the method should be inapplicable (with the means employed) in the case of the molecules of the pure liquids themselves. Experiments were undertaken to see if Pockels' conclusions were justified, using mixtures of calcium benzoate and aniline. The crystalline powder was stirred into the liquid, and after allowing more or less time for the particles to settle, the upper liquid was decanted and used in the experiments. The magnetic field alone gave a means of classifying the liquids according to the size of the particles, the magnetic double refraction tending more or less rapidly to a "saturation" value. This saturation value is much more quickly reached with mixtures containing large particles, for which the Brownian movements have relatively less importance. Repeating the experiments (previously described) relative to the superposition of the two fields, it was found that the departures from the additive law noted before are correspondingly more noticeable as the particles are larger. Thus Pockels' conclusions are verified in the sense that the effects sought for are sharper with more intense fields, and with the fields used, as the particles are larger. But the experiments also show that results can be obtained when the saturation has not been reached for either of the fields employed. It appears to be necessary to increase considerably the values of the fields used, and also to test the validity of Pockels' conclusions for pure liquids. A. W.

460. Effect of Electric Field on Spectrum Lines. E. Warburg. (Deutsch. Phys. Gesell., Verh. 15. 23. pp. 1259-1266, Dec. 15, 1918.)—It is here shown that Bohr's theory applied to Rutherford's model atom will explain to a certain degree of accuracy the effect of magnetic and electric fields on spectrum lines. Quantitative results are, however, so far from being in agreement with the observations of Stark [see Abstract No. 288 (1914)] that modification or amplification of the theory is necessary. In view of this discrepancy between the observed values and those calculated from the theory, it appears worthy of notice that according to the theory the electric effect is proportional to Planck's action-quantum h , while the magnetic effect is independent of h . A. W.

461. Arc Spectrum of Nickel in International Units. S. Hamm. (Zeitschr. wiss. Phot. 18. pp. 105-180, Dec., 1918. Extract from Dissertation, Bonn.)—Earlier measurements of the lines in the spectrum of nickel are briefly dealt with. In the present research, pure Ni rods 1 cm. diam. were used in the direct-current arc, the current being 6 to 7 amps. For photographing the spectrum a Rowland concave grating was employed, with 20,000 lines to the inch and a radius of 6.84 m. The dispersion was such that in the second order 1 mm. of the photographic plate corresponded to 1 Å. Wave-length tables, in international units, are given of many hundred lines, ranging from $\lambda 7122.276$ to $\lambda 2165.502$, the results of Exner and Haschek and of Hasselberg being included for comparison. A. W.

462. Electrodeless Spectra of Hydrogen. I. Masson. (Nature, 92. p. 508, Jan. 1, 1914.)—While making experiments on the apparent production of neon and helium during electric discharges, the author noticed an effect which does not seem to have been previously observed. A powerful oscillatory discharge is produced in eight or nine coils of wire from two Leyden jars, with a spark-gap of about 2 in. in parallel, connected to a large coil which is run from the main supply. Set in the coils of wire is a glass bulb of about 300 cm.³ capacity, provided below with a small bulb containing coconut
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charcoal, and connected by a side-tube and tap with a mercury pump. After evacuating, heating, and "washing out" the bulb with hydrogen, when pure hydrogen is admitted at a fairly low pressure and the discharge is passed, the glow is bluish in colour, and shows both hydrogen and mercury spectra; but if the charcoal bulb be cooled in liquid air so that mercury-vapour and any other impurities are removed, the glow is of a brilliant rose-colour, and shows only hydrogen lines. If the pressure is reduced, however, to a value somewhere below 1 mm., there appears in the middle of the rose ring a fairly bright blue zone; and whereas the former shows both the simple and complex spectra of hydrogen, the blue zone shows nothing but the elementary line-spectrum; and, moreover, the blue line $\lambda 4861$ is more intense than the red line. Further reduction of pressure causes the obliteration of the blue zone by the spreading inwards of the rose ring. A. W.

463. Ultra-red Absorption of Gases. E[va] v. Bahr. (Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1150-1158, Nov. 15, 1918.)—It has previously been shown [see Abstract No. 1946 (1918)] that the Bjerrum conception of the ultra-red absorption spectra of gases is in many respects in good agreement with the experimental results. By an indirect method it was also shown that the double bands are made up of many narrow bands. The research has been continued with HCl and CO₂. Using a quartz prism the absorption bands of HCl at 8.5μ and of CO₂ at 2.7μ were investigated; a considerably greater resolution of the bands was obtained than in earlier work. Curves are reproduced showing that in the HCl band there are 12 maxima, and from the positions of these maxima the rotation frequency of the molecule was calculated according to Bjerrum's theory. The absorption of CO₂ at 2.7μ consists of two different absorption bands, which may probably be resolved into a double band when a slightly greater dispersion than that employed is used. A. W.

464. Band Spectrum of Aluminium. A. de Gramont. (Comptes Rendus, 157. pp. 1864-1868, Dec. 22, 1918.)—Observations were made of the spectra obtained by introducing metallic Al and various Al compounds into the high-temperature oxy-acetylene flame. In addition to the five bands already known, a sixth was found, more refrangible than the others. The wave-lengths of the heads of the secondary bands in this new band, which is much weaker than the other five, are: 4880.5, 4851.7, 4878.6, 4894.4, 4418.3, 4481.0, 4447.6, 4462.6. All the bands are degraded, like the others, towards the red, and the first head is not the most intense. A large number of minerals investigated exhibited the Al band spectrum. (*Erratum*, Ibid. 158. p. 79, Jan. 5, 1914.) A. W.

465. Spectroscopy of Flames. A. Reis. (Deutsch. Phys. Gesell., Verh. 15. 28. pp. 1247-1258, Dec. 15, 1918.)—Describes an investigation of the different spectra arising in the following flames:—Ammonia-oxygen, cyanogen-oxygen, cyanogen-air, acetylene-oxygen, hydrogen-oxygen, hydrogen-air, coal-gas-air. A mixed jet was used in each case. A. W.

466. Kathode Spectrum of Helium. P. G. Nutting. (Nature, 92. p. 401, Dec. 4, 1918.)—Various articles have recently appeared dealing with a spectrum frequently associated with the spectrum of He and by some attributed to impurities in the He. If a helium tube be prepared with *disc*
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electrodes, carefully freed from impurities, and operated on a transformer or continuous current (*not* on an induction-coil discharge), the region about the cathode will be filled with a bright pink glow. The spectrum of this cathode glow is the spectrum in question. If care be taken to avoid stray light from the anode column, it may be obtained quite free from the ordinary (anode) spectrum of He. When the disruptive discharge from an induction coil is used to excite the tube, or the tube is viewed end-on through a cylindrical electrode, the two spectra appear mixed in various proportions. In the author's work on the helium tube as a primary light-standard, scores of tubes were prepared and operated as above described. It was noted that the cathode glow was pale and greyish, until the last traces of impurities had disappeared, when it turned to a bright pink. In fact, the appearance of the pink cathode glow is an infallible criterion for the purity of the He, a spectroscopic being unnecessary. Most gases exhibit two, and a few three quite distinct spectra: the anode (primary) and cathode spectra, and the secondary spectrum obtained with a disruptive discharge. Nitrogen is an example of a gas having all three spectra. Helium is one of the few gases and vapours the primary and secondary spectra of which are alike, but the anode and cathode spectra of which are quite different. A. W.

467. High-frequency Spectra of the Elements. H. G. J. Moseley. (Phil. Mag. 26. pp. 1024-1084, Dec., 1918.)—In the absence of any available method of spectrum analysis, the characteristic types of Röntgen radiation, which an atom emits when suitably excited, have hitherto been described in terms of their absorption in Al. The present paper contains a description of a method of photographing the high-frequency spectra, which makes the analysis of the Röntgen rays as simple as any other branch of spectroscopy. The author intends first to make a general survey of the principal types of high-frequency radiation and then to examine the spectra of a few elements in greater detail and with great accuracy. The results already obtained show that such data have an important bearing on the question of the internal structure of the atom, and strongly support the views of Rutherford and of Bohr [see Abstracts Nos. 1980 (1918) and 15 (1914)]. Kaye has shown that an element excited by a stream of sufficiently rapid cathode rays emits its characteristic Röntgen radiation. He used as targets a number of substances mounted on a truck inside an exhausted tube, a magnetic device enabling each target to be brought in turn into the line of fire. The apparatus was modified to suit the present work. The cathode stream was concentrated on to a small area of the target, and a Pt plate furnished with a fine vertical slit was placed immediately in front of the part bombarded. The tube was exhausted by a Gaede pump, charcoal in liquid air being also sometimes used to remove water-vapour. The Röntgen rays, after passing through the slit, emerged through an Al window 0.02 mm. thick. The rest of the radiation was shut off by a lead box which surrounded the tube. The rays fell on a cleavage face of a crystal of potassium ferrocyanide which was mounted on the prism-table of a spectrometer. A photographic plate was mounted on the spectrometer arm, and both the plate and slit, S, were 17 cm. from the axis. If P is the part of the crystal where the radiation strikes the surface and L the line on the photographic plate corresponding to radiation of definite frequency with glancing angle of incidence θ , then $2\theta = 180^\circ - \text{SPL} = 180^\circ - \text{SAL}$, A being the position of the axis of the spectrometer table. A method is given for determining the angle SAL. Hence θ is known. The following elements were examined: Pt, Ta, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, VOL. XVII.—A.—1914.

and Zn. It is seen from the photographs that the spectrum of each element consists of two lines. Of these the stronger has been called α and the weaker β . The lines found on any of the plates besides α and β were most probably all due to impurities. No other lines have been found; but a search over a wide range of wave-lengths has been made only for one or two elements, and perhaps prolonged exposures, which have not yet been attempted, will show more complex spectra. The prevalence of lines due to impurities suggests that this may prove a powerful method of chemical analysis. Its advantage over ordinary spectroscopic methods lies in the simplicity of the spectra and the impossibility of one substance masking the radiation from another. The similarity of the different spectra is shown by the fact that the two lines α and β remain approximately constant, not only in relative intensity, but also in relative wave-length. The frequency of β increases, however, slightly faster than that of α . The same two lines, α strong and β weak, constitute the rhodium spectrum examined by Bragg, and they are obviously in some way closely related. One or two photographs taken with the radiation from Pt gave results in good agreement with those obtained by the electrical method, but no trace of the elaborate system of bands described by de Broglie in the reflection from rock-salt was encountered. A discussion is given of the meaning of the wave-lengths found for the principal spectrum-line α . The discussion is based on Bohr's theory of atomic structure. A. W.

468. Spectrum of Water-vapour in Magnetic Field. H. Deslandres and L. d'Azambuja. (*Comptes Rendus*, 157, pp. 814-820, Nov. 10, 1918.)—Observations made on the spectrum of water-vapour with a spectrograph of moderate dispersion, and a Weiss electromagnet giving a field of 82,000 gauss in a gap of about 2 mm., showed that while there was no sign of doubling of the rays, there was a decided displacement of all the lines. Detailed examination of the amounts of shift for various lines enables a selection into series to be made which may prove useful in cases of very complex spectra. C. P. B.

469. Energy-distribution in Emission Spectra of Phosphorescent Compounds. P. Borissow. (*Ann. d. Physik*, 42. 6, pp. 1821-1858, Dec. 28, 1918.)—From the researches here described it appears that the energy-distribution for each single phosphorescence band in the spectrum can be represented by a probability formula. A method is given by which the complete resolution of the phosphorescence spectrum into single bands may be accomplished. This resolution was effected completely for the first time with CaBi and SrBi. The analogies between the Bi bands in Ca and Sr are established for four bands and are considered in detail. The wave-lengths of the emission maxima of the α - and β -bands are always greater with increased temperature, though at the lowest temperatures they are at first smaller for the α -bands; they can for the higher temperatures be represented as a linear function of the temperature. For the β -bands the wave-lengths of the emission maxima show no dependence on the temperature. The principal (α -) bands of CaBi- and SrBi-phosphore are broader at higher temperatures, as Lenard has previously found for most bands. [See also Abstracts Nos. 726 (1905) and 810 (1910).] A. W.

470. Phosphorescence of Mercury-vapour. F. S. Phillips. (*Nature*, 92, p. 401, Dec. 4, 1918.)—The author has previously given an account of a persistent fluorescence of mercury-vapour produced by excitation with 2536 light, obtained from a quartz mercury lamp [see Abstract No. 1937 (1918)].

When the fluorescent vapour is placed in a strong magnetic field, the mercury lamp being cooled so that the line $\lambda 2586$ is sharp, the field increases the intensity of the fluorescence several times. If the lamp is allowed to warm up so that the $\lambda 2586$ line becomes broadened and reversed, the opposite effect is obtained, *i.e.* the fluorescence decreases in intensity with the field. In this latter case the field strength that produces the greatest diminution in intensity increases with the temperature of the lamp. The ordinary fluorescence produced by the light from the Cd spark is not affected by the magnetic field. Further work is in progress with a view to obtaining a satisfactory explanation of the persistent fluorescence and the various phenomena connected with it.

A. W.

471. Effect of Magnetic Field on Intensity of Fluorescence. W. Steubing. (Deutsch. Phys. Gesell., Verh. 15. 22. pp. 1181-1186, Nov. 30, 1918.)—The author finds that a magnetic field causes a 85 % loss of intensity in the fluorescence produced in iodine vapour by white light: all the lines lose equally in intensity. Also the resonance spectra show the same effect. No effect was noticed with mercury, selenium, sodium, tellurium, or anthracene vapour. A corresponding absorption effect in iodine could not be detected.

J. M.

472. Colour Photography of Luminescence. J. M. Lohr. (Journ. Phys. Chem. 17. pp. 675-681, Nov., 1918.)—Details are given respecting the successful use of colour-photography to determine the quality of the visible light emitted during cathode luminescence and also the quality of light emitted by the flames of various substances. It is found that the Dufay plates are not particularly sensitive to the very faint cathodoluminescence of some of the halogen salts, while in the use of the Dufay colour plates for lantern-slides the intense heat and light of the lantern place a limitation on the length of time that the slide should be left in the lantern.

A. E. G.

473. Luminescence. E. F. Farnau. (Journ. Phys. Chem. 17. pp. 687-696, Nov., 1918.)—The author has examined the luminescence produced in the halogen salts and, in some cases, the carbonates and sulphates of Na, K, Li, Rb, Cs, Cd, Zn, and Hg by cathode rays, canal rays, ultra-violet light, heating after excitation, trituration, and chemical action. The conclusion is drawn that luminescence in all its forms is due to chemical action, increase of the rate of reaction by rise of temperature or by addition of a catalytic agent increasing the luminescence. The quality of the luminescence is but slightly altered either by change of temperature or by the nature of the catalytic agent. The nature of the luminescence generally depends almost entirely on the kation, although in a few cases a specific effect of the anion is observed. The quality of the luminescence is independent of the mode of production, although in many instances it can be changed to an entirely different kind of light by particular modes of excitation, such as rapid chemical action or canal rays. The chemical reaction producing a given luminescence can in some cases be formulated.

T. H. P.

474. Zeeman-effect of H_α in Weak Magnetic Fields. P. Erochin. (Ann. d. Physik, 42. 5. pp. 1064-1060, Dec. 2, 1918.)—Two Leyden jars about 40 cm. high and an inductance of 0.0045 henry were used with the hydrogen vacuum tube, which was operated on a transformer. With the above capacity and inductance the two components of H_α were almost completely separated in the absence of any field. The Zeeman-effect for the p -components of the

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line H_{α} is such that the constituents of the doublet approach one another as the applied field becomes stronger, and for the highest fields used (14,500 gauss) appear to merge into a single line which is considerably broader than the single constituents. The displacement of the constituents towards one another appears to be proportional at first to the square of the field strength. With the s-components at first only a broadening of the constituents is noticeable, which soon merge into one another. From about 5000 gauss the beginning of the separation into a triplet is apparent, with the outer component on the red side the most intense. Various effects are noted as the field is increased to about 11,000 gauss. A. W.

475. Atomic Models and Röntgen-ray Spectra. F. A. Lindemann. (Nature, 92, pp. 500-501, Jan. 1, 1914.)—Moseley has recently described his measurements of the characteristic Röntgen-ray lines of various metals [see Abstract No. 467 (1914)]. He has calculated the wave-lengths of one-half of the lines he observed, assuming Bohr's atom and supposing the positive charge on the nucleus to correspond to the place of the element in the periodic table, as suggested by van den Broek. He concludes that the agreement between calculated and observed wave-lengths strongly supports the views of Rutherford and of Bohr. To Lindemann it appears that Moseley's research really only supports the views of Rutherford and of van den Broek. He proposes to show in detail in a subsequent paper that the relation between the wave-length and the positive charge may be obtained in a large number of different ways. For the present it may suffice to point out that it may be derived from a simple consideration of the dimensions of the quantities involved. The frequency ν can only be supposed to depend upon the magnitude of the positive and negative charges Ne and ne , upon the mass m of the moving charge, upon the distance r between the charges, and upon Planck's element of action h . As Nne^2 , m , r , and h must be combined in such a way that the dimension of the resulting quantity is T^{-1} we have $(NnML^3T^{-2})^x M^y L^z (ML^2T^{-1})^u = T^{-1}$, whence $y = x - 1$, $z = x - 2$, and $u = 1 - 2x$. If $x = 0$ we find $\nu = \text{const.} \times h/mr^2$, the constant being of the order unity, as Einstein pointed out. Assuming the characteristic Röntgen rays to be due to the movement of a single electron, we must suppose r to be proportional to $1/N$, where N corresponds to the number of free positive charges on the nucleus found by Rutherford and van den Broek. Roughly speaking, this would be the case if the repulsive force keeping the electrons away from the centre were proportional to $1/r^2$ as suggested by Thomson. If $x = 1/2$ we find $\nu = \text{const.} \times \sqrt{(nNe^2/mr^2)}$. This formula is interesting, as it does not contain h , and so may be derived from the ordinary laws of mechanics. It also reduces to Moseley's formula if $r \sim 1/N$. If $x = 1$, $\nu = \text{const.} \times nN^2e^2/hr$. If one electron is supposed to oscillate, r must again be assumed proportional to $1/N$ to fit the facts. If all $n = N$ electrons oscillate, r must be supposed to be constant. In this case the formula accounts also for the second series of lines which Moseley's formula fails to do. They may be calculated with great exactitude by putting $\nu = \text{const.} \times N(N-1)e^2/hr$, which corresponds to an atom which has lost one electron. If we put $x = 2$, we find $\nu = \text{const.} \times n^2N^2e^2m/h^2$, which is obviously identical with Moseley's formula, if we suppose only one electron to oscillate. The agreement of Bohr's constant with experimental data does not appear to the author convincing in view of the large number of arbitrary assumptions in his derivation. All the above formulæ are independent of the choice of any special model. They are selected so that the expression for ν is successively independent of e^2 , h .

m , or r . They would seem to prove that Moseley's figures need not be taken to confirm Bohr's views on the constitution of the atom. The only essential assumption common to them all is that N should correspond to the place of the element in the periodic table approximately, as suggested by Rutherford and van den Broek, and it would seem therefore that this hypothesis only can be said to be supported by Moseley's experiments. A. W.

476. *Atomic Models and Röntgen-ray Spectra*. N. Bohr and H. Moseley. (Nature, 92. pp. 558-564, Jan. 15, 1914.)—Lindemann has recently [see preceding Abstract] dealt with the approximate agreement between Moseley's experiments and Bohr's theory. Bohr here criticises Lindemann's method of procedure, which he does not think is justified. He argues that just as little as the five quantities ν , r , Nne^2 , m , and h , the four quantities r , Nne^2 , m , and h may be considered as independent of each other. By a consideration of dimensions a relation can be obtained between these four quantities, and if this relation is introduced in Lindemann's expressions for ν , all the different expressions become identical. A consideration of dimensions only cannot give the numerical factors which determine the exact values for the frequencies of the spectrum of an element; for this, more detailed assumptions as to the constitution of the atom and the mechanism of the emission of radiation must be introduced. Moseley also criticises Lindemann's method, and advances reasons for the conclusion that his experiments support the hypothesis that h is a fundamental factor in the atom. He also states that he has not succeeded in obtaining agreement between his results and the vibrations considered by Nicholson. Two things suggest that either Bohr's theory, or Moseley's interpretation of it, requires modification. In the first place, it fails to account for the second weaker line in each spectrum. In the second place, it is difficult to see how a ring of four electrons can store up enough energy to vibrate as a whole. A. W.

477. *Atomic Models and Röntgen-ray Spectra*. J. W. Nicholson. (Nature, 92. pp. 583-584, Jan. 22, 1914.)—It is universally assumed that the atom of an element can form a Saturnian system with more than one ring of rotating electrons, and this idea is used in particular by Moseley in the theoretical discussion of his recent experiments [see Abstract No. 467 (1914)]. But it is shown in an Adams prize essay, not yet published in full, that this is impossible. If the law of repulsion between two electrons, or of attraction between electron and nucleus, is that of the inverse square, more than one coplanar ring cannot exist. All the electrons in any plane must lie in the same ring, and even if they are in different planes the radii of the rings must be nearly equal. A simple case is quoted in illustration. This conclusion not only belongs to any ordinary dynamical theory of the rings, but to Bohr's theory also; for Bohr supposes that the *steady rotation* of the system can be derived by ordinary mechanics, and, in fact, the equation so derived is vital to his formula for spectra. So if Bohr's theory is to remain, then the idea of concentric rings in the atom, with Röntgen radiation coming from an inner ring, must be abandoned. For any way of avoiding the present conclusion, for example, by making a change in the law of attraction in the immediate neighbourhood of the nucleus, at once destroys the formula on which Moseley bases his view that his experiments support Bohr's theory. It is shown that Röntgen radiation may be given out, according to Bohr's theory, by a single ring, without a serious reduction in its radius. In this case the calcium Röntgen-ray spectrum, for example, means exactly the same thing as

the ordinary hydrogen spectrum, and no element should show such Röntgen-ray spectra until N , the number of units in the nucleus, becomes large. The Röntgen-ray or Balmer spectrum of helium, for example, would have a principal line, $\lambda = 694.5 \times 10^{-8}$, between the ultra-violet and Röntgen-ray regions. But there is a serious difficulty when the number of units in the nucleus is so much greater than n , the number of electrons. For Ca Moseley takes $N = 20$, $n = 4$. Possible explanations of this difficulty are suggested. Moseley states that he has not found a correspondence between the Röntgen-ray spectra and the vibrations of the element nebium treated in one of Nicholson's papers. This is not to be expected, for the two investigations are unrelated. The simple-ring atoms used to interpret astrophysical spectra are supposed to have a *simple* nucleus, or to contain no α -particles, and to be incapable of giving series spectra. They are not identical with ordinary atoms, into which, however, they appear to change in the stars which follow nebulae in order of evolution. A. W.

478. *Spectral Analysis of Röntgen Radiation by Means of Reflection and Heat Motion.* P. Debye. (Deutsch. Phys. Gesell., Verh. 15. 17. pp. 857-875, Sept. 15, 1918.)—This is a mathematical discussion of the fundamental hypothesis according to which the characteristic distribution of intensity of the interference and reflection images can be regarded as solely the consequence of the heat motion. The amplitude and intensity of the reflected monochromatic radiation for a given arrangement of the atom are first considered; then the mean observable intensity, and next the mean monochromatic distribution of intensity are discussed. Finally spectral analysis by reflection, and the deficiency of the proposed explanation and its cause are dealt with. [See Abstracts Nos. 604 and 1292 (1918).] J. J. S.

479. *Interference of X-rays.* L. S. Ornstein. (Phys. Zeitschr. 14. pp. 941-947, Oct. 1, 1918.)—Develops Bragg's theory of X-ray reflection [Abstracts Nos. 989 and 1778 (1918)] by a different mathematical method. Bragg's curve is explained, and brought into agreement with the intensity of the patches on Laue's photographs, by assuming that the incident radiation consists of a number of waves of different frequencies upon which a pulse with a thickness small in comparison with the wave-length is superposed. The ratio of these is of the same order as the number of effective surfaces. Laue's photographs give diffraction images of the order zero, from which no conclusions as regards wave-length can be drawn. Bragg's method of examining the intensity of reflected radiation at different angles of incidence yields values for the wave-length of the fluorescent radiation. Interesting conclusions can be drawn regarding the structure of crystals from both methods. E. E. F.

480. *Life of Uranium and Radium.* S. Meyer. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1065-1094, June, 1918.)—The fundamental data for the calculation of the average life of Ur are discussed. The ionisation current, produced by the α -particles from 1 gm. $\text{UrI} + \text{UrII}$, is found to be 1.87 e.s. unit, which is in agreement with McCoy and Ashman's value [see Abstract No. 154 (1909)]. Assuming ranges of 2.5 cm. and 2.9 cm. for α -rays from UrI and UrII , and the number of ions produced to be 1.26×10^6 and 1.87×10^6 respectively, then the following relation holds:—

$$i = 1.87 = n(1.26 + 1.87) 10^6 \times e,$$

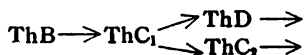
where n is the number of α -particles given off per sec. by each Ur product.
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If $\epsilon = 4.65 \times 10^{-10}$ e.s. unit (Rutherford's value) then $n = 1.12 \times 10^4$. If $\epsilon = 4.78 \times 10^{-10}$ e.s. unit (Millikan's value) then $n = 1.09 \times 10^4$. Hence, taking Rutherford's value for ϵ , the number of α -particles emitted per sec. from $\text{UrI} + \text{UrII}$ is 2.24×10^4 , whilst Rutherford and Geiger found it to be 2.87×10^4 . This slightly higher value found by Rutherford and Geiger is explained by the fact that possibly there might be a small quantity of ionium present in the preparation of Ur used—the presence of 10^{-6} gm. of Io-Th would account for the difference between the two values. The author, by using Ur salt freed from ionium found that $\lambda_{\text{UrI}} = 4.4 \times 10^{-18} (\text{sec.})^{-1}$, $\tau = 7.2 \times 10^{10}$ years, $T = 5.0 \times 10^9$ years. Taking 8.4×10^{10} as the number of α -particles emitted per sec. from 1 gm. of Ra , the value 8.2×10^{-7} or 8.8×10^{-7} is obtained for the ratio Ra/Ur (when equilibrium exists), according as we take $\epsilon = 4.78 \times 10^{-10}$ or 4.65×10^{-10} .

By a second method based on the relation $\lambda_{\text{UrI}} = \lambda_{\text{Ra}} \times 288/226 \times \text{Ra}/\text{Ur}$ another value of λ_{UrI} is calculated. From observations on the production of RaEm from ionium extending over a period of 4 years, the following data were deduced: $\lambda_{\text{Ra}} = 1.26 \times 10^{-11} (\text{sec.})^{-1}$, $\tau_{\text{Ra}} = 2500$ years, $T_{\text{Ra}} = 1780$ years. Substituting the values of λ_{Ra} and Ra/Ur in the above equation we obtain the following mean values: $\lambda_{\text{UrI}} = 4.8 \times 10^{-18} (\text{sec.})^{-1}$, $\tau_{\text{UrI}} = 7.87 \times 10^9$ years, $T_{\text{UrI}} = 5.1 \times 10^9$ years, which agree very closely with those obtained by the first method. It is found that the most consistent results are obtained if the following values be taken for the various quantities concerned:—

$$\begin{aligned} \lambda_{\text{Ra}} &= 1.26 \times 10^{-11} (\text{sec.})^{-1}, \tau_{\text{Ra}} = 8.4 \times 10^{10}, T_{\text{Ra}} = 1780 \text{ years} \\ \lambda_{\text{UrI}} &= 4.8 \times 10^{-18} (\text{sec.})^{-1}, \tau_{\text{UrI}} = 1.1 \times 10^9, T_{\text{UrI}} = 5.0 \times 10^9 \text{ years} \\ \epsilon &= 4.78 \times 10^{-10} \text{ e.s. unit.} \end{aligned} \quad \text{E. A. O.}$$

481. *The Thorium Series.* P. Beer and K. Fajans. (Phys. Zeitschr. 14. pp. 947-951, Oct. 1, 1918.)—Evidence is brought forward in support of the scheme of Marsden and Darwin for the division of the thorium series at ThC_1 :



The version supported by L. Meitner, that there are two separable products of ThB , was probably suggested by the volatility of ThC_1 chloride in presence of SnCl_2 . E. E. F.

482. *Parallelisms in Radio-active Transformations.* K. Fajans. (Phys. Zeitschr. 14. pp. 951-958, Oct. 1, 1918.)—In view of the behaviour of the thorium products [see preceding Abstract] it is probable that the branching of the three radio-active series does not take place at the B-terms, but at the C_1 -terms. The branching is due to the simultaneous emission of α - and β -particles. In the case of RaC_1 , the α emission is only made by three atoms in 10,000, in the case of ThC_1 by 85 per cent. The life periods of the products appear to obey the general rule previously enunciated that the α -radiators of the same series decreases as the atomic weight falls, whereas the life period of the β -radiators increases. In the actinium series the ratio of atoms emitting α -particles to those emitting β -particles must at the branching point be even larger than in the Th series. This is a conclusion from the dependence of the stability of a product on its atomic weight. E. E. F.

483. *Reflection of Röntgen Rays.* M. de Broglie, E. Jacot. (Nature, 92. pp. 428-429, Dec. 11, 1918.)—M. de Broglie has recently described a new VOL. XVII.—A.—1914.

method of investigating the reflection of Röntgen rays from a crystal [see Abstract No. 248 (1914)]. The present note gives a few further details. Up to the present only the doublet $11^{\circ} 17'$ and $11^{\circ} 88'$ described by Moseley and Darwin has been identified by the new method. The spectra contain also a number of bright lines about two octaves shorter than these, and the continuous spectrum is contained within about the same limits. These numbers may be used in interpretations of diffraction Röntgen patterns, as they were obtained with tubes of the same hardness as those used for producing these latter. The arrangement enables the spectra of different orders to be easily distinguished, as the interposition of an absorbing layer cuts out the soft rays, but does not weaken appreciably the hard rays of the second and higher orders. It is convenient also for absorption experiments; thus a piece of Pt-foil of 0.2 mm. thickness showed transparent bands. The exact measurements will be published shortly, together with the results of some experiments upon the effect of changing the temperature of the crystal. Experiments by Jacot seem to show that a regularly reflected beam of Röntgen rays on incidence at a second crystal surface again suffers optical reflection; but the degree of reflection is dependent on the orientation of this second reflector relative to the first. The second reflector is mounted on a suitably adapted goniometer, and the photographic plate is mounted immediately behind the crystal. The beam is a pencil 1.5 mm. in diam. When the two reflectors are parallel the impression on the plate, due to the two reflections, is clear. But as the second reflector is rotated about an axis given by the reflected beam from the first and fixed reflector the optically reflected radiation from the second reflector—other conditions remaining constant—diminishes very appreciably. As the angle between the reflectors is increased from 0° to 90° , the impression recorded on the photographic plate diminishes in intensity. For an angle of 20° it is still clear; for angles in the neighbourhood of 50° it is not always detectable; and for an angle of 90° it is very rarely detectable in the first stages of developing, and it is then so faint that it never appears on the finished print. These results, then, would show that the regularly reflected beam of Röntgen rays is appreciably polarised in a way exactly analogous to that of ordinary light. The selectively reflected Röntgen rays seem to show the same effects as does the regularly reflected beam. Selectively reflected radiation is always detectable after the second reflection, but this seems to be due to the selectively reflected radiation produced at the second reflector by the unpolarised portion of the beam regularly reflected at the first reflector. The application of a theory of polarisation to explain the above results is supported by the fact that in the case of two reflections by parallel reflectors, the proportion of Röntgen rays reflected at the second reflector is invariably greater than the proportion of rays reflected at the first. This might be expected if vibrations perpendicular to the plane of incidence are to be reflected to a greater extent than those in the plane of incidence. The proportion of such vibrations is larger in the beam incident on the second reflector than in the original beam, and a greater portion of radiation would be reflected at the second reflector than could be at the first. For the case of parallel reflectors and incidence of the primary beam on the first at the polarising angle, the reflection at the second should be complete. A. W.

484. *Tables of Exponential Functions relative to Radium Emanation.* L. Kolowrat. (Le Radium, 10. pp. 889-892, Dec., 1918.)—Five-figure tables are given of $e^{-\lambda t}$ and $(1 - e^{-\lambda t})/\lambda$, the former representing the decay of radium emanation and the latter its growth when the production per hour is

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taken as unity. The value taken for the disintegration constant λ is 0.00751 (hr.⁻¹) [see Abstracts Nos. 566 (1910) and 824 (1912)]. E. M.

485. Variations of Ranges of Individual α -Particles. F. Friedmann. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1269-1289, July, 1918.)—The author has made an experimental investigation of the decrease in the total number of α -particles which traverse a given distance from the source. In the case of polonium the falling-off of the number towards the end of the range is found to agree with the theoretical results of Herzfeld [Abstract No. 1587 (1912)] calculated from the probability variations in the number of molecules encountered in the paths of the individual α -particles. E. M.

486. β -Rays of Radium Products. J. Danysz. (Journ. de Physique, 8. Ser. 5. pp. 949-961, Dec., 1918.)—A collected account of the author's work on the velocities of the β -particles from Ra B, C, D, and E, together with that by Danysz and Duane on the total charge carried by the α - and β -particles of Ra (Em + A + B + C) [Abstracts Nos. 79 and 815 (1918)]. With regard to the diminution in the speed of β -particles in passing through matter, the experiments show that foils of either Al, Sn, Cu, Ag, or Au of the same mass per unit area produce the same decrease. For foils of weight 0.01 gm. per cm.² the decrease in the value of $H\rho$ (ρ = radius of curvature in field of strength H) varies from about 106 for a pencil of rays for which $H\rho = 1500$, to 42 for a pencil for which $H\rho = 5800$. E. M.

487. Analysis of the γ -Rays of the Thorium and Actinium Products. E. Rutherford and H. Richardson. (Phil. Mag. 26. pp. 937-948, Dec., 1918.)—In continuation of previous work [Abstracts Nos. 1675 (1918) and 94 (1914)] the primary γ -rays from the various radio-active products are found to be as follows:—

Element.	Atomic weight.	Absorption coefficient μ in Al.	Mass. Absorption Coefficient μ/d in Al.
Radium B	214	280 } (cm.) ⁻¹ 40 } 0.51 } "	85 } (cm.) ⁻¹ 14.7 } " 0.188 } "
Radium C	214	0.115 } "	0.0424 } "
Radium D	210	45 } " 0.99 } "	16.5 } " 0.86 } "
Radium E	210	similar types to D but very feeble.	
Mesothorium 2	228	26 } (cm.) ⁻¹ 0.116 } "	9.5 } " 0.0428* } "
Thorium B.....	212	160 } " 82 } " 0.86 } "	59 } " 11.8 } " 0.18 } "
Thorium D.....	208	0.096 } "	0.085 } "
Radio-actinium	—	25 } " 0.190 } "	9.2 } " 0.070 } "
Actinium B.....	—	120 } " 81 } "	44 } " 11.4 } "
Actinium D	—	0.45 } " 0.198 } "	0.165 } " 0.078 } "

[* Abstractor's correction.]

The rays may conveniently be divided into four types : (1) The soft radiations from the B-products which may vary from $\mu = 120$ to $\mu = 280$. (2) A more penetrating type from $\mu = 26$ to $\mu = 45$ probably corresponding to characteristic radiations of the L series. (3) A penetrating type from the B-products varying from $\mu = 0.86$ to $\mu = 0.51$. (4) A very penetrating type varying from $\mu = 0.115$ to $\mu = 0.198$, probably corresponding to characteristic radiations of the "K" series.

According to the views of Russell, Fajans, and Soddy [Abstract No. 170 (1914), etc.], the B-products of the three radio-active families are to be regarded as chemically identical, although they differ by about 2 units in their atomic weights. It would appear probable that this should also involve an identity in the electronic distribution and of the magnitude of the charge on the nucleus. If the γ -rays set up are due to the vibration of the electronic systems, it would be anticipated that the types of γ -rays emitted would be identical for such products. The experiments show that while there is undoubtedly close analogy between the γ -rays of the three B-products, yet the differences of penetrating power are well marked. By comparison of the penetrating powers of the γ -rays from corresponding products of the three series the authors deduce the atomic weight of Ac to be about 228, the general evidence indicating further that it is derived from Ur after the expulsion of two α -particles. E. M.

488. Existence of Uranium Y. F. Soddy. (Phil. Mag. 27. pp. 215-221, Jan., 1914.)—The author has confirmed the existence of Antonoff's Ur_Y, the existence of which was recently questioned by Fleck [see Abstracts Nos. 1690 (1918) and 102 (1914)]. Ur_Y appears "isotopic," or chemically non-separable from UrX₁. E. M.

489. γ -Rays of Polonium, Radium, and Radio-actinium. A. S. Russell and J. Chadwick. (Phil. Mag. 27. pp. 112-125, Jan., 1914.)—The experiments are in continuation of those described in Abstracts Nos. 481 and 1165 (1918), in which the presence was established of soft γ -rays accompanying the α -rays of various products. The chemical methods of separating pure polonium and radio-actinium are described. The results show that Po emits primary γ -rays of one type only with μ/D in Al = 215 cm⁻¹. The α -rays of Po are able to excite a soft γ -radiation in Cu, probably the characteristic radiation in Series L. No appreciable γ -radiation is excited under similar circumstances in Pt or Pb.

Radium itself freed from its products is found to emit three types of γ -rays with values of μ/D in Al of 180, 6, and 0.1 cm⁻¹. The intensity of the γ -radiation of Ra itself is from 1 to 1½ per cent. of that of Ra in equilibrium with its short-lived products. The results show further that Radio-Ac emits two types of γ -rays, the values of μ/D in Al being 8 and 0.1. E. M.

490. Delta Rays from Gases. N. Campbell. (Phil. Mag. 27. pp. 88-91, Jan., 1914.)—In investigating the question of δ -radiation from gases by measurements of the current between two electrodes it must be considered that if the pressure is too great the electrons ejected in ionisation lose their initial velocities by collision with the molecules before they can make their presence felt at the electrodes. Again, if the electric field is too great the initial velocities of the electrons are inappreciable compared with those that they acquire in moving through the field. The author has therefore studied the question from observations of the current through a gas with a very

small electric field and a pressure so low that collisions between the electrons liberated and the molecules of the gas are rare. An important factor which enters into the consideration is the affinity of the molecules of the gas for electrons—a question which has been studied by Franck and Hertz [Abstract No. 810 (1914)]. The author finally concludes that δ -rays are emitted from ionised molecules of gases with velocities of the same order of magnitude as those from metals. E. M.

491. Measurements of Penetrating γ -Radiation from 1000 to 4000 Metres. V. F. Hess. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1481–1486, July, 1918.)—The author has continued his observations [Abstracts Nos. 828 (1918), etc.] of the ionisation in a closed vessel during balloon ascents. The measurements show that above 2000 m. there is a fairly rapid increase in the ionisation, *i.e.* an increase in the penetrating γ -radiation. At this height the penetrating γ -rays from the earth itself are negligible, whilst those from any small amount of radium emanation in the air must be, at any rate, less than at the surface. The author thus concludes that a great part of the ordinary penetrating γ -radiation cannot come from the known radio-active constituents of the earth or atmosphere. E. M.

492. Penetrating Radiation. K. Bergwitz. (Phys. Zeitschr. 14. pp. 958–956, Oct. 1, 1918.)—Shows that the Wulf radiation-meter ("Strahler"), a string electrometer with two parallel threads, is subject to temperature and pressure in a manner which invalidates it for comparisons of ionisation currents at different times and places. The distortion of the case by varying atmospheric pressure is not serious except in the case of balloon ascents, but sunlight and warm air-currents have a very considerable action which it is difficult to eliminate. E. E. F.

493. Measurements of the Earth's Penetrating Radiation with a Wulf Electrometer. J. C. McLennan and A. R. McLeod. (Phil. Mag. 26. pp. 740–752, Oct., 1918.)—The experiments described are in continuation of those of McLennan [Abstract No. 617 (1918)]. The Wulf electrometer is, however, shown to be far more suitable than an electroscope for measurements in which steadiness of the instrument is not possible, *e.g.* on board a ship. The essential feature of the instrument is the use of two conducting quartz fibres attached at both ends instead of the usual gold-leaf. The distance apart of the fibres gives a measure of their potential. The results of the observations show that the number of ions produced per cm^3 in a closed zinc receiver is 4.8 on a vessel in the Atlantic and about the same when the receiver is immersed in water so that all penetrating radiation is cut off. This residual ionisation of about 4 ions per cm^3 must therefore either come from the walls of the zinc or from some very penetrating radiation not yet known, since it has been shown by J. J. Thomson and by Langevin and Rey [Abstract No. 1247 (1918)] that ionisation cannot be produced by ordinary collisions between molecules. However, Simpson and Wright, using a zinc receiver of 27 litres' capacity obtained 4 ions per cm^3 as the minimum ionisation, while the receiver used by the present authors had only 2 litres' capacity. The agreement between the results thus does not support the view that the residual ionisation is due to radiation from the walls of the receiver. E. M.

494. Note on the Colour of Zircons and its Radio-active Origin. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 89. pp. 405–407, Jan., 1914.)

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495. Exposed Stem Correction for Mercury Thermometers. G. Dimmer. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1489-1460, July, 1918.)—The various formulæ and tables which have been used for correcting mercury thermometers for exposed stem are discussed, and in particular those of Rimbach which are quoted in Landolt and Börnstein's tables. Rimbach gives a series of formulæ for various temperature-ranges, but the author shows that the experimental results from which these formulæ are deduced can be adequately represented by the simple Kopp formula, $k = na(t_1 - t_2)$, where k is the correction, n the number of degrees exposed, a the apparent coefficient of expansion of the mercury, t_1 the temperature recorded by the thermometer, and t_2 that indicated by a thermometer whose bulb is at the centre of the exposed stem. Experiments are then described in which measurements of the correction are made with thermometers of Jena glass (N. 16) for the temperature-range -80° to $+100^\circ$ C., and with thermometers of borosilicate glass (N. 59) for the range 0° to 400° C. The author concludes that the tables given by Rimbach for thermometers of Jena glass are inaccurate; the results of his own experiments are given in tabular form, and are shown to be well represented by the formulæ $k = 0.000156n(t_1 - t_2)$ and $k = 0.000168n(t_1 - t_2)$ respectively. F. J. H.

496. Thermal Conductivity of Mercury by the Impressed Velocity Method. H. R. Nettleton. (Phys. Soc., Proc. 26. pp. 28-40; Discussion, pp. 40-42, Dec., 1918.)—The paper gives an account of the determination of the thermal conductivity of mercury at room temperature by the method already described by the author [see Abstract No. 1112 (1910)]. The mercury is contained within a vacuum-jacketed siphon tube about 17 cm.² in cross-section, which is heated at the top and maintained ice-cold at its lower extremity. The distribution of temperature down this tube is determined with the aid of a single thermo-junction, while the mercury is at the same time flowing uniformly up the tube at speeds ranging from 870 to 1420 gm. per 15 mins. The calorimetry is thus essentially continuous-flow calorimetry within the temperate gradient, the quantity of heat passing down the mercury being controlled and measured by the flow of liquid. The wires forming the thermo-elements—viz., iron and constantan—are contained within a vertical tube of 6 mm. diam. through the glass of which the wires are fused. This carrier tube is placed in the mercury column in such a way that the thermo-junction can be raised or lowered from outside by a cathetometer, or can be rotated in a horizontal plane to test the horizontality of the isothermals; these were found to be remarkably horizontal. Making use of the formula developed in the paper referred to [*loc. cit.*] the author obtains for the thermal conductivity of mercury at 15.5° C. the value 0.0201 in c.g.s. units. The advantages of the method lie in the simplicity of the calorimetry and in the fact that temperature ratios rather than temperature differences are required. F. J. H.

497. Thermal Conductivity of Liquids. E. Hernqvist. (Ark. för Mat. Astron. och Fysik, Stockholm, 8. No. 88. pp. 1-9, 1918.)—The thermal con-
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ductivities of hexane, heptane, and octane were determined by the flow of heat through a disc-shaped mass of liquid from one gilded copper-plate to a second copper-plate cooled with ice. The constant of the equation in one experiment varied only from 0.70 to 0.78 in ten successive readings, and five or six such series were used to determine the conductivity of each liquid. The resulting values in c.g.s. units were :—

Hexane	0.000864
Heptane	0.000887
Octane	0.000875

T. M. L.

498. Use of Light-filters with the Holborn-Kurlbaum Pyrometer. M. v. Pirani. (Deutsch. Phys. Gesell., Verh. 15. 17. pp. 826-888, Sept. 15, 1918.)—The action of the Holborn-Kurlbaum pyrometer is based on the comparison of the brightness of a luminous surface with that of a glow-lamp filament, the intrinsic brilliancy of the latter being modified until it appears identical with that of the surface studied. The instrument can thus be applied to quite small luminous objects. But in general it will not be possible to obtain exact resemblance in colour, which makes accurate comparison difficult. It has, therefore, been proposed to analyse the light from the sources studied, and to compare only the brightness in a small region of the spectrum. But spectro-photometric apparatus of this kind adds to the complexity of the instrument, and attempts have been made to use instead glass or gelatine colour-filters. The author describes a series of researches on the transparency and optical centre of gravity of four filters of this kind. He finds that the optical centre of gravity with varying temperature only alters as follows : 465-467, 537-542, 572-577, and 658-672 μ ; these regions are so limited as to make the filters suitable for use with the pyrometer, but for temperature measurements the author prefers the two latter ones. The use of dark glasses as a means of diminishing the incident light was also investigated, and found to be satisfactory.

J. S. D.

499. Determination of the Relative Humidity of the Air by means of the Refractometer. F. Giraud. (Journ. de Physique, 8. Ser. 5. pp. 900-902, Nov., 1918.)—Glycerine when exposed to the air has the property of absorbing a certain quantity of water-vapour, the amount of which depends upon the humidity of the air; variations in the strength of the solution of water in glycerine can easily be observed by means of a refractometer to determine the index of refraction of the liquid. As the index also varies with the temperature it is necessary to reduce all the observations to a constant temperature (20° C.). After this correction is applied the formula to calculate the relative humidity is found to be $H = 100 (1 - \alpha^x)$,

$$\text{where } \alpha = (n - 1.888) / (1.4747 - 1.888) = (n - 1.888) / 0.1417.$$

Here n = index of refraction of the solution at 20° C.,

$x = n^{2.000}$, and H = relative humidity.

The formula is found to hold for air of humidity varying between 50 and 94 per cent. It will be seen that, for saturation $n = 1.888$, and for perfectly dry air n would be 1.4747, supposing the formula still to hold in that case.

In order to make an observation a cigarette paper is dipped in glycerine and placed upon the upper prism of the refractometer. A table calculated from the formula is given to avoid the necessity for computation, while the correction for temperature of the refractive index is also given.

R. C.

500. General Comparison of Vapour Pressures. J. M. Crafts. (*Comptes Rendus*, 157. pp. 1403-1405, Dec. 22, 1913.)—A number of varied substances are found to obey the relation, $T - T' = (T''_a - T'''_a)C$, where T and T' are the boiling-points of any particular substance and T''_a and T'''_a those of a standard substance at the pressures P and P' respectively, while C is a constant independent of the temperature. As standard substance, naphthalene is chosen owing to its purity and stability. For various pressures ranging from 89 to 1741 mm., the above expression gives results in good accord with the observed values for nitrogen, oxygen, SO_2 , CO_2 , bromine, *n*-hexane, benzene, ethyl acetate, phenol, aniline, benzophenone, mercury and sulphur. The values of the expression $20C/T$, where T represents the absolute boiling-point under 760 mm. pressure, are in all cases about 0.04. With hydrogen, chlorine, water, ethyl and isoamyl alcohols, and acetic and isobutyric acids, the above equation does not hold, but excellent agreement is given by $T - T' = (T''_a - T'''_a)[C \pm c(t - t)]$. T. H. P.

501. Vapour Pressures of Carbon Compounds. A. Schulze. (*Phys. Zeitschr.* 14. pp. 922-926, Oct. 1, 1913.)—The vapour pressures were determined by a modification of Dumas' method. A large glass bulb had a small bulb attached to it by means of a capillary tube. After vaporising the substance under examination so as to fill both bulbs at atmospheric pressure, the bulb was sealed and the small bulb was plunged into liquid air, thus condensing all the vapour into the small bulb. The latter was then fused off and weighed, while the large bulb, now highly exhausted, was filled with water to determine its volume. The author gives a list of carbon compounds with their temperatures, vapour densities, and resulting molecular weights. The figures show that CS_2 contains complex molecules. Nitrobenzol is also associated in the state of vapour, as it is when liquid, but the alcohols, which form strongly associated liquids, are monomolecular as vapours. Ethyl ether, acetone, benzol, and hexane are also non-associated. E. E. F.

502. Thermodynamics of Solids and Liquids. W. Nernst. (*Preuss. Akad. Wiss. Berlin, Ber.* 52. pp. 972-985, 1913.)—A theoretical treatise on this subject dealing with the electrical, magnetic, and chemical properties as well as the thermal, elastic, and other physical properties. Special reference is made to low temperatures and the T^3 law for specific heats. E. H. B.

503. Rotation Energy of Diatomic Gas on the Newer Quantum Hypothesis. E. Holm. (*Ann. d. Physik*, 42. 6. pp. 1811-1820, Dec. 28, 1913.)—The newer formula given by Planck for the energy of a linear resonator is based on the assumption that the resonator can receive *all possible* quantities of energy, but that the resonators whose energies lie in the same *elementary region of energy*, i.e. all those whose energies lie between $(n - 1)h\nu$ and $nh\nu$ are equally distributed.

By an application of this modified quantum hypothesis is here derived the molecular energy of rotation for a diatomic gas which thus, contrary to the result of Ehrenfest, shows an unbroken increase of the molecular heat by rising temperatures. [See Abstract No. 601 (1913).] E. H. B.

504. Relations between Dilatational and Thermodynamical Coefficients. T. Peczkalski. (*Comptes Rendus*, 157. pp. 584-586, Oct. 18, 1913.)—Utilising the characteristic differential equation, $dt = dv/\alpha + dp/\beta$, where α , β , p , v ,
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and t have the usual meanings, the author deduces expressions for a small quantity of heat, dQ , and uses them to obtain the three adiabatic equations,

$$t - t_0 = \frac{C - c}{C\beta} \log(p/p_0) = \frac{C - c}{ca} \log(v/v_0), \quad pv^{\frac{C}{c}} = \text{const.},$$

which apply in all cases where α , β , C , and c do not vary with p , v , and t ; C and c are the specific heats at constant pressure and constant volume respectively. From an expression for the velocity of sound, viz. $V = \sqrt{C/c \cdot \beta/\alpha \cdot p/\rho}$, similarly developed the values of C/c for water and ether at atmospheric pressure and temperature are calculated. (*Erratum*, *Ibid.* p. 811, Nov. 8, 1918.)

F. J. H.

505. Boltzmann's Principle of Entropy and Probability. K. F. Herzfeld. (*Akad. Wiss. Wien, Ber.* 122. 2a. pp. 1558-1561, July, 1918.)—A mathematical discussion of the equation embodying Boltzmann's principle, viz., $S = k \log W$. [See Abstract No. 815 (1911).]

E. H. B.

506. On Thermodynamics. K. v. Wesendonk. (*Deutsch. Phys. Gesell., Verh.* 15. 17. pp. 889-856, Sept. 15, 1918.)—A theoretical discussion dealing with the views of Nernst, Wegscheider, and others; unsuitable for abstracting.

507. Radiation of Gases. L. Zehnder (*Deutsch. Phys. Gesell., Verh.* 15. 24. pp. 1817-1882, Dec. 80, 1918.)—A descriptive survey of modern views. [See Abstract No. 1076 (1912).]

E. H. B.

508. The Constant in the Radiation Law. E. Bauer. (*Journ. de Physique*, 8. Ser. 5. pp. 641-649, Aug., 1918.)—Remarks on the work of J. de Boissoudy [Abstract No. 1807 (1918)].

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

509. Quantities of Electricity Smaller than the Electronic Charge. F. Ehrenhaft. (Deutsch. Phys. Gesell., Verh. 15. 22. pp. 1187-1202, Nov. 80, and 24. pp. 1850-1852, Dec. 80, 1918.)—By the observation of ultramicroscopic particles and the measurement of their charge and mass the author concludes that the electronic charge is not Nature's unit of electricity. It is here suggested that an electron may be a stable arrangement of yet smaller constituents, *sub-electrons*. Repeatedly in the experiments there appear charges which are of the order of *three-quarters*, the *half*, and the *quarter* of the electronic charge 4.8×10^{-10} e.s. unit. The experiments include observations on mercury particles in CO, and in nitrogen. E. H. B.

510. Dielectric and Unipolar Induction. K. Fehrle. (Ann. d. Physik, 42. 6. pp. 1109-1128, Dec. 28, 1918.)—An experimental research from which the following conclusions are drawn. Suppose an earthed cylinder carried by a metal disc to be concentrically placed inside another metal cylinder carrying a coil through which a current circulates, then—(1) If the outer cylinder rotates, it receives a charge provided the inner air does not rotate with it. (2) If the inner air rotates with it, it receives no charge. (3) The charge in case 1 is not dependent on the inhomogeneity of the field, but simply on the flux through the cross-section of the coil cylinder. (4) If the coil is rotated at the same speed in the opposite sense, the inner cylinder acquires a charge of the same sign as is developed by turning the inner cylinder, but the numerical value is different. Relativity between the motions of the cylinder and the coil, without consideration of the dielectric, do not give equality of inductive actions. (5) A charge of the inner cylinder by rotation of the coil, in consequence of the induction in the stationary system, is impossible. (6) Relativity between the motions with inclusion of the dielectric gives accord with the principle of relativity. [See Abstract No. 1859 (1912).] E. H. B.

511. Statistical Electron Theory. J. Kroo. (Ann. d. Physik, 42. 6. pp. 1854-1896, Dec. 28, 1918.)—Mathematical. E. H. B.

512. Minkowski's Fundamental Equations of Electrodynamics. II. E. Waelach. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1095-1106, June, 1918.)—Quaternion and binary forms of the equations are treated. [See Abstract No. 118 (1914).] E. H. B.

513. Moving Media. E. Lohr. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1487-1530, July, 1918.)—A mathematical discussion of the electromagnetic theory by G. Jaumann for moving media. [See Abstracts Nos. 1291 (1906) and 1698 (1908).] E. H. B.

514. Theory of Dielectric Lag. K. W. Wagner. (Elektrotechn. Zeitschr. 84. pp. 1279-1281, Nov. 6, 1918.)—This theory is not concerned with the mechanism of dielectric phenomena but with their mathematical representation. The displacement in an imperfect dielectric does not instantly follow
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changes in the electric field, but lags to some extent behind. The displacement D in a perfect dielectric is given by the formula $D = \lambda E / 4\pi V^2$; the lag in an imperfect dielectric as shown by Hopkinson is given by $\Delta D = -(\lambda \cdot \Delta E / 4\pi V^2) \cdot \psi(t)$, where $\psi(t)$ is a function of the time since the application of the change of field, ΔE . The function ψ can be represented according to v. Schweidler by a series of exponential terms of the form $\psi(t) = \sum k_m e^{-t/T_m}$, where k_m and T_m are constants which are adjusted by trial to fit the experimental results. In order that the phenomena of dielectrics may be susceptible to calculation a knowledge of the function ψ is necessary. On the analogy of the Wiechert theory of elastic creep the series is assumed to extend to ∞ , and the time-constants T are supposed to be grouped in a definite manner about a most probable value T_0 . This leads to a somewhat intricate expression for ψ , from which the absorption current is obtained in the form—

$$i = \int_{-\infty}^{+\infty} e^{-bx^2 - x - (t/T_0) \cdot e^{-x}} \cdot dx, \text{ where } z = \log T/T_0.$$

The absorption current is plotted from this integral for a variety of values of the characteristic constant b which measures the closeness of the distribution of T about T_0 . Knowing ψ , formulæ can also be deduced which give the dependence on the frequency of capacity and of energy losses in the dielectric for alternating currents, and, further, the influence of temperature is considered. In every case the calculated curves are found to be in satisfactory agreement with the known properties of dielectrics. H. W. M.

515. *Errors in Measurements of Atmospheric Electricity.* C. Dorno. (Phys. Zeitschr. 14. pp. 956-960, Oct. 1, 1918.)—Confirms Bergwitz's conclusions [Abstract No. 492 (1914)]. Silvered quartz fibres are unsuitable for measuring the lower atmospheric ionisation currents on account of the unequal expansion of the quartz and the silvering, which induces strains. Measurements of penetrating radiation at various times of the day will have to be revised on account of these instrumental errors. E. E. F.

516. *The Atmospheric Potential Gradient, and a Theory as to the Cause of its Connection with other Phenomena in Atmospheric Electricity.* W. F. G. Swann. (Terrestrial Magnetism, 18. pp. 168-184, Dec., 1918.)—A mathematical investigation into the electrical conditions which would be expected to prevail in the atmosphere starting with the assumption of a potential which increases with height above the ground and utilising the theory of conduction of electricity in gases. Certain broad postulates are necessary. Thus the earth and the upper layers of the atmosphere are taken as two charged parallel plates, and the method of deducing the variation of force between the plates is on the lines of that adopted by J. J. Thomson in his "Conduction of Electricity through Gases." Minor assumptions necessary are that the specific velocities of positive and negative ions are equal to one another (known not to be strictly true) and that a steady state has been attained in the atmosphere. A weak point in the theory is introduced by the uncertainty as to what value should be assigned to " q " the rate of formation of ions in the air. Of the conclusions reached, some are in good agreement with the observed facts, others show some divergence and point to a modification of the theory being required, while a third class have not come within the scope of observational work in the past and suggest interesting lines for future research. With regard to the variation of potential gradient with height the theory indicates that the

gradient should fall off very rapidly in the first 15 m. above the ground, and after this the decrease becomes inappreciable. If the assumption of a fairly intensely ionised layer of air in the immediate vicinity of the ground be introduced, the deduced potential gradient would be brought more into harmony with the observed state. The theory suggests that the large fluctuations which are found to exist in the immediate neighbourhood of the ground are local effects and that much steadier conditions prevail at greater heights, say 50–100 m.

J. S. DI.

DISCHARGE AND OSCILLATIONS.

517. Flame Couples. G. Moreau. (*Comptes Rendus*, 157, pp. 922–924, Nov. 17, 1918.)—The author has realised with pure flames, or flames charged with saline vapours, couples comparable to voltaic piles. The simplest combination is obtained by introducing into the flame of a Bunsen burner two plates of Pt, the one bare, the other covered with a deposit capable of emitting, when heated, many negative corpuscles. This deposit is obtained by fusing several mgm. of an alkaline salt or by evaporating several drops of a solution of a salt of an alkaline-earth, leaving a thin layer of oxide. The two plates serve as the electrodes of the couple: bare Pt—pure flame—sensitised Pt. If the plates are joined a current is observed of the order of 0.1 micro-amp., and it is remarkably constant when the thickness of the deposit is sufficient. There is no trace of polarisation. If E is the e.m.f. of the couple, the bare Pt being positive, and I_c the mean normal kinetic energy of a corpuscle of charge e issuing from the deposit, and I_p from the Pt, respectively, then $E = (I_c - I_p)/e$. With electrodes at 1400° abs., the following values were found for E : Electrode covered with CaO, 0.55 volt; BaO, 0.70 volt; SrO, 0.54 volt; K_2CO_3 , 0.68 volt; Na_2CO_3 , 0.69 volt; RbCl, 0.56 volt. If the bare Pt electrode is cold enough for I_p to be neglected the e.m.f. E_1 should increase and be given by $E_1 = I_p/e$. Such a couple, with a cold positive electrode, can be obtained by using a Pt tube, cooled with a current of air, in conjunction with one of the sensitised electrodes maintained at 1400° . With the series: cold Pt—pure flame—Pt covered with CaO, E_1 was found to be 1.18 volts. If in this couple the sensitised electrode is replaced by a plate of bare Pt at 1400° , we have the series: cold Pt—pure flame—hot Pt noted by Becquerel, Buff, etc. Its e.m.f. $E_2 = I_p/e$. E_2 was found to be 0.55 volt. The difference $E_1 - E_2 = 0.61$ volt. This is close to the value 0.55 volt measured for the couple: bare Pt—flame—Pt covered with CaO. Taking $e = 4.2 \times 10^{-10}$ e.s. unit, the above formulæ give for u , the velocity of emission of corpuscles at 1400° , the values: CaO, 6.8×10^7 cm./sec.; Pt, 4.4×10^7 cm./sec. The other oxides and alkaline salts give velocities between 6 and 7×10^7 cm./sec. The mass of a corpuscle is taken as 0.8×10^{-27} gm. Another series of couples is obtained by charging the flame with the vapour of an alkaline salt capable of being strongly ionised. The e.m.f. is always smaller than that of the corresponding couple with a pure flame, and the difference Δ increases with the concentration of the saline vapour. The resulting current also increases with the concentration of the vapour and can have a value of many microamps.

A. W.

518. Apparent Variations in the Specific Velocity of Ions of Flames with the Field. A. Bernini. (*N. Cimento*, 6. Ser. 6. pp. 212–219, Sept., 1918.)—Although the results obtained for the specific velocity of the ions issuing from a gas-flame by the three methods of Thomson, Child [Abstract No. 847 (1901)], and Gianfranceschi [Abstract No. 927 (1906)] agree satisfactorily, yet

in all cases the value of the velocity exhibits appreciable increase with the strength of field [see Abstract No. 1714 (1911)]. It might be assumed that the variation in the potential of the flame produced by change of the strength of field would not be accompanied by any other modification in the conditions. But experiment shows that such is not the case, and the author supposes that the anomalous course of the ionic velocity originates in peculiar conditions in which, with respect to the production of ions, the flame is found according to the potential to which it is brought. Making use of an improved apparatus, in which the Thomson machine is replaced by the more simple system of a single jet and a single conductor [see Abstract No. 1405 (1912)], the author finds that the conditions of the flame are modified by change in the potential, although the nature of these modifications is not made clear.

T. H. P.

519. *Residual Ionisation in Gases.* J. C. McLennan. (Nature, 92, p. 424, Dec. 11, 1918.)—Various observers agree that the natural ionisation in air confined in "clean zinc vessels is about 8 or 9 ions per cm^3 per sec. when the observations are made on land, and about 4 ions per cm^3 per sec. when the observations are made directly over the surface of large bodies of water. The reduction in the number of ions per cm^3 per sec. has been shown to be due to the absorption of the earth's penetrating radiation by the water [see Abstract No. 617 (1918)]. On a recent voyage from England to Canada the author made observations in a zinc vessel containing either air or hydrogen. The mean ionisation was found to correspond to the production of 4.65 ions per cm^3 per sec. in air, and 1.8 in hydrogen. On land, in a building with no radio-active material in the neighbourhood, the production of ions was 8.8 per cm^3 per sec. in air, and 2.0 in hydrogen. From this it follows that the penetrating radiation at the surface of the earth produces about twenty times as many ions in air as in hydrogen. Since the residual ionisation in hydrogen on the ocean was nearly 40 per cent. of that in air, it is evident that the residual ionisation in these two gases could not have been due to a radiation of the type of the earth's penetrating rays. Experiments should therefore be directed to determining whether this residual effect in gases is due to the action of an easily absorbed radiation from the walls of the vessel in which the gases are confined, or whether it has its origin in a disruption of the molecules occurring either spontaneously or through the agency of collisions. [See Abstract No. 498 (1914).]

E. M.

520. *Electrical Conductivity imparted to Liquid Air by α -Rays.* J. C. McLennan and D. A. Keys. (Phil. Mag. 26, pp. 876-894, Nov., 1918. Paper read before the Roy. Soc. of Canada, May 26, 1918.)—In the experiments two electrodes, one of which was coated with polonium, were placed about 5 mm. apart in carefully filtered liquid air, and the current between them measured for different voltages. Saturation could not be obtained, but with the highest potential used, 1850 volts, the current was $1/576$ of that produced in air at atmospheric pressure for complete absorption of the α -rays. It was also shown that in the absence of any ionising radiation the conductivity of liquid air is much the same as that of ordinary clean air at atmospheric pressure. Experiments were also made in the same way on the ionisation current produced in air at a pressure of 100 atmos., and in this case the max. current (with 1850 volts) was $1/16$ of the saturation current in air at atmospheric pressure. The mobilities of the positive and negative ions in air at 116 atmos. were determined to be 5.29×10^{-4} and 6.22×10^{-4} respectively, the ratio

being 1·18. From various results obtained in air at high pressure the authors deduce that polonium emits an ionising radiation much more penetrating than its α -particles.

E. M.

521. Sealing-wax as a Source of Lime for the Wehnelt Kathode. N[ellie] N. Hornor. (Amer. Journ. Sci. 86. pp. 591-597, Dec., 1918.)—It is shown that when Bank of England sealing-wax is used as the source of lime there is a falling off in the activity with the time. When a maximum is reached most of the electrons are emitted during the first run. When the discharge is broken while the heating current is maintained there is a slight falling off in the negative stream. These results are exactly opposite to those obtained by Willows and Picton using calcium oxide on a Pt-strip. The saturation voltage is found to be 200 volts. There is a falling off in the maxima for successive runs, and the steady current for any given run is usually much smaller than that for the preceding run with the same lime.

A. E. G.

522. Special Case of Gaseous Conduction. N. Campbell. (Phil. Mag. 26. pp. 912-924, Nov., 1918.)—A theory of the conduction of electricity in an ionised gas is sketched for such experimental conditions that the effects of recombination of the ions are inappreciable compared with those of their diffusion. From the results obtained it appears that if such conditions could be realised the form of the "saturation curve" of the ionised gas should depend on nothing but the temperature of the gas. This was found to be the case with some curves obtained by the author with air, hydrogen, and CO, at pressures less than atmospheric. The gas was contained in a parallel-plate guard-ring condenser, the plates of which were less than 8 mm. apart, and was ionised by α - or Röntgen-rays which passed through a layer of Al-foil covering a large circular hole in one plate of the condenser. The form of the saturation curves is inexplicable on the theory of conduction which applies to cases where recombination is the important process, but is almost exactly that given by the theory referred to, being within certain limits independent of the nature and pressure of the gas, of the distance between the electrodes, and of the intensity of the ionisation. The limits are probably set by the influence of recombination on the one hand, and on the other, by the finite initial velocities of the δ -rays emitted in ionisation. Certain inexplicable anomalies were found when hard β - and γ -rays were used for ionisation. These anomalies are connected with certain peculiar actions taking place at the metal electrodes, which, it appears, do not always absorb all the ions falling on them. By sooting the metal plates of the condenser curves similar to those with α - and Röntgen-rays were obtained.

F. J. H.

523. Origin of Thermal Ionisation from Carbon. J. N. Pring. (Roy. Soc., Proc. Ser. A. 89. pp. 844-860, Nov. 1, 1918.)—It has been shown by the present author and A. Parker that the ionisation which is produced by carbon at high temperatures, and in the presence of gases at low pressures, is reduced to a much smaller order of magnitude by eliminating impurities from the carbon, and by exhausting to a high degree the containing vessel [Abstract No. 542 (1912)]. These results threw considerable doubt on the whole basis of the theory of electronic emission from incandescent solids. In discussing these results Richardson admits that the ionisation originally measured by him in the case of carbon was largely influenced by the presence of impurities leading to chemical reaction. The result of this was to lead to an

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abnormally high value being given to the constant A in the expression $Ae^{1/2}e^{-Q/2kT}$ which was deduced to represent, on the basis of the thermionic theory, the relation between ionisation and temperature. By revising the constants from which the values in this formula are derived, the formula was made to follow much more closely the experimental results of Pring and Parker, though it still gave values considerably higher than the latter, and did not agree with the observed influence of temperature. It was, however, maintained that the fundamental theory put forward by Richardson, accounting for the relation between ionisation and temperature, was not disturbed. The aim of the present work is to see if any direct electronic emission can be attributed to incandescent carbon, when the large ionisation effects, which were found in the earlier work to be due to chemical action, are more completely removed. For this purpose the purification of the carbon and the exhaustion of the surrounding vessel are carried out more extensively than before, and the effect on the ionisation at definite temperatures is carefully measured. A series of experiments is also made in which small quantities of the highly purified gases—He, Ar, N, CO, CO₂ are admitted to the vessel at known pressures to see if any relation could be traced between the ionisation and the relative chemical action of these gases on carbon. The results show that the large currents hitherto observed were derived from some reaction between the carbon and the gas. It is also shown that a still further reduction in the ionisation is brought about by eliminating further the absorbed gases from the carbon. By admitting known amounts of different pure gases to the carbon the ionisation produced is directly proportional to the known chemical activity of these gases. The progress of absorption of the gas by the carbon and its evolution can, moreover, be traced by ionisation currents. While it is difficult to prove definitely that there is no electronic emission from the heated carbon itself, it is obvious that it is exceedingly small compared with the ionisation which can be attributed to ordinary chemical change. The small residual currents which are observed in high vacua after prolonged heating are not greater than would be anticipated when taking into account the great difficulty of removing the last traces of gas.

A. E. G.

524. Theory of Ionisation by Collision. B. Davis. (*Ann. d. Physik*, 42. 4. pp. 807-814, Nov. 4, 1918.)—The author first recapitulates his theory for the minimum kinetic energy which a negative ion must have in order to ionise a molecule by impact [Abstract No. 295 (1907)]. It is shown that if α is the number of ionising impacts which a negative ion makes in passing through 1 cm. of a gas, l the mean free path of the ion, X the potential gradient, λ_0 the minimum path which results in ionisation, so that $X\lambda$ is the ionising potential, then—

$$\alpha l = e^{-\frac{\lambda_0}{l}} + \frac{\lambda_0}{l} Ei\left(-\frac{\lambda_0}{l}\right),$$

where Ei represents the exponential integral. The mean free path, l , is $4\sqrt{2}$ times the mean free path of the molecules of the gas, the factor 4 arising from the assumption that the electron behaves as a point and the factor $\sqrt{2}$, because under the influence of the electric field the electrons velocity is greater than the velocity of agitation of the molecules. It is deduced from the fact that experiment agrees with theory [Abstract No. 865 (1912)] which assumes a spherical molecule, that probably the electron does not actually touch the molecule, but gets to such a distance that its repulsion of the

electrons of the molecule is operative. As it is extremely improbable that the molecule is actually spherical, it would appear that the resultant field of its electrons has a spherical distribution. E. M.

525. Potential Attained by Photoelectric Cells in Darkness. J. W. Woodrow. (Phys. Rev. 2. Ser. 2. p. 198, Sept., 1918.)—The author made some experiments which seemed to show that strongly photoelectric metals liberated positive particles when kept in total darkness [see Abstract No. 111 (1918)]. Further experiments were made to determine the exact nature of the charge obtained from the photoelectric metal, and it was shown conclusively that this charge was due to a leak across the surface of the glass insulation, from the potassium which will be at a positive potential with respect to the Pt electrode. The increased current at the higher temperatures is probably due to the increased conductivity of the glass and the condensation of the vapour of the metal on the walls of the cell. S. H. Anderson has shown that with alternating fields applied to a photoelectric cell in darkness there is no indication of the current which would be expected if the metal liberated any kind of positive particles. J. J. S.

526. Abnormal Electric Dispersion. E. Schrödinger. (Deutsch. Phys. Gesell., Verh. 15. 22. pp. 1167-1172, Nov. 30, 1918.)—A theoretical discussion reaching the following suggestions as to the requisite experimental researches. (1) The influence of temperature on the middle part of the dispersion curve should be investigated. (2) The researches of Colley and Obolensky should be continued and extended over as large a part of the spectrum as possible. [See Abstract No. 446 (1918) and P. Debye, Ibid. 15. 16. p. 777, 1918.] E. H. B.

527. Canal-ray Secondary Radiation. H. Baerwald. (Ann. d. Physik, 42. 6. pp. 1287-1310, Dec. 28, 1918.)—A comparison of the author's methods and results with those of Füchtbauer. A. E. G.

528. Radiation of Electric Waves in Dispersive Media. W. Esmarch. (Ann. d. Physik, 42. 6. pp. 1257-1272, Dec. 28, 1918.)—A theoretical investigation in which the following points are specially noteworthy. (1) Two methods are developed which express the secondary waves generated by the passage of plane waves in a medium laden with electrons. The superposition of the primary wave on those sent out from these electrons gives a progressive wave whose extinction and phase velocity agree with the known values on the ordinary dispersion theory. (2) The reflected wave arises at all places in the medium traversed by the incident wave and not only in the neighbourhood of the limiting layer. E. H. B.

529. The Virtual Anode in Tubes for Magnetic Rays. A. Righi. (Accad. Lincei, Atti, 22. pp. 256-268, Sept. 28, 1918. Phil. Mag. 26. pp. 848-857, Nov., 1918.)—Experiments show that, through the action of the magnetic field there appears, with unusual extension, a beam of cathodic rays known as cathodic rays of the second kind, or magnetokathodic rays, or magnetic rays, and that on the prolongation of them another one may appear having the colour and character of the positive column of the usual discharge. To this column, which constitutes a second phenomenon due to the magnetic rays, More and Rieman gave the name of "induced column." But as there is in this case no real phenomenon of induction, it is now suggested to change the

name to "secondary column." The principal experiment is carried out by observing the action produced on the secondary column by a feeble transverse magnetic field obtained, for example, by means of a coil. The effect which may be observed is a deformation of the secondary column such as might be produced if, in a given region of the same, an anode (virtual anode) existed and two cathodes were at the ends of the tube. Assuming the truth of the author's theory of the nature of the magnetic rays this virtual anode may be explained as follows :—The pairs ion-electron are incessantly destroyed through molecular collision, but new ones are formed in a quantity which decreases as we go towards the places where the intensity of the field becomes less. Thus it happens that positive ions and electrons produced by the scission of the doublets are driven by their speed towards the bottom of the tube, which most of the latter will easily reach, while the positive ions will stop before then and form the virtual anode. The place where these positive ions arrive depends on the speed impressed on the doublets by the magnetic force, and, consequently, it depends (1) on the area enclosed by the orbits of the electron satellite; (2) on the speed with which it is moving in this orbit; (3) on the mass of the positive ion. A comparison of the curves relative to the various gases certainly leads to the conclusion that the distance of the virtual anode from the cathode depends on the mass of the positive ion. Results of some interest are also obtained by using gaseous mixtures. The causes why More and Rieman failed to obtain constant results are considered, and More and Mauchly's work is also discussed. [See also Abstract No. 219 (1918).] A. E. G.

530. *Occluded Gases in Vacuum Tubes.* R. W. Lawson. (Phys. Zeitschr. 14. pp. 988-941, Oct. 1, 1918.)—Brings forward further evidence in favour of the persistent occlusion of gases in vacuum tubes [see Abstract No. 879 (1918)]. After 12 hours' discharge and subsequent exhaustion, a vacuum tube with Pt electrodes showed an intense spark spectrum of oxygen. Aluminium electrodes could not be made to yield oxygen, Ne, Ar, or He. CO was evolved for many hours from Al electrodes, but not from Pt electrodes. There were traces of hydrocarbons, indicated by the band 4815 \AA ., but these were always occluded in the capillary tubes, not in the electrodes. E. E. F.

531. *Electric Discharge Phenomena in Rotating Silica Bulbs.* R. J. Strutt. (Roy. Soc., Proc. Ser. A. 89. pp. 840-844, Nov. 1, 1918.)—The late F. J. Jervis-Smith described some experiments on this subject, without, however, offering any interpretation of his results [see Abstracts Nos. 884 and 1822 (1908)]. His fundamental experiment was one in which the exhausted bulb is placed near a body charged to 1000 volts or more. When the bulb is rotated, a luminous glow is maintained within it. This is now explained by the flow of induced currents inside the bulb. In Jervis-Smith's third paper he describes luminosity produced by rubbing the outside of the rotating silica vessel. The cause of luminosity is shown to be not materially different from what it was in the previous case. If a brush discharge from an induction coil is merely allowed to play over a highly exhausted silica bulb, the bulb remains brightly luminous, sometimes for several minutes. This is shown to be connected with electrification of the outside surface. In another experiment of Jervis-Smith a silica glow bulb was rotated as before. The camelhair rubber, after being in contact with the bulb, was removed, and no glow was visible; but on establishing the magnetic field (about 800 c.g.s. units intensity), the bulb instantly

glowed brightly, the glow lasting in some cases 8½ mins. before it died out. When pointed pole-pieces were used on either side of the rotating bulb, a bright equatorial band about 5 mm. wide of greenish glow was generated. The explanation now offered is that each pole of the magnet, acting merely as an earthed conductor, lowers the potential of the inner surface of the bulb near it, so that these two portions of the surface tend to act as kathodes.

The electric force may not be enough to cause discharge, but when the magnet is excited it produces a magnetic force parallel to the electric force, and this, as is known, lowers the discharge potential so that discharge can occur. At the same time a beam of "magnetic rays" proceeds from each kathode towards the other, along the magnetic lines. These constitute the luminous band described.

A. E. G.

532. *Low-potential Discharges in High Vacua.* J. S. Townsend. (Phil. Mag. 26. pp. 780-782, Oct., 1918.)—The paper is a discussion of the explanation given by Strutt of the low-potential discharge in high vacua which he obtained by means of a magnetic field [see Abstract No. 1866 (1918)]. Attention is first drawn to the mistake made in considering that the electrons leaving the kathode in an ordinary vacuum tube are unable to ionise the gas until they have fallen through the kathode fall of potential. Measurements of the effects obtained by collisions show that an electron ionises a molecule when it collides with a velocity acquired under a potential-fall of 25 volts, so that many of the molecules in the dark space are ionised. An explanation of the effect of the magnetic field is then given which obviates the necessity for distinguishing between electrons which have travelled through large distances and those which have travelled through small, but which have fallen through the same p.d. In the high vacua of Strutt's experiments the electrons produce very little effect in traversing the distance between the concentric cylinders when the magnetic field is zero, since they meet with so few molecules. The number of collisions in the spiral path when the magnetic field is on is, however, very much larger, so that the effect of the magnetic field is the same as if the pressure were increased in the ratio of the two paths so far as ions generated by electrons are concerned. The p.d. required to produce the discharge is thus reduced to the value corresponding to a higher pressure.

F. J. H.

533. *Low-potential Discharges in High Vacua.* F. Horton. (Phil. Mag. 26. pp. 902-906, Nov., 1918.)—During some recent experiments made by the author, the effect of a transverse magnetic field upon the negative emission from heated salts was observed under varying conditions of gas pressure and voltage. The results of a typical experiment are quoted, and shown to be in keeping with the theory of ionisation by collision, thus bearing out Townsend's explanation [see preceding Abstract] of the low-potential discharge obtained by Strutt.

F. J. H.

534. *Energy Transferred by Electromagnetic Waves.* M. Reich. (Phys. Zeitschr. 14. pp. 924-928, Oct. 1, 1918.)—Quotes the result of some experiments made between Göttingen and either Cologne or Strassburg, which show that Hertz's theory of electromagnetic radiation is substantially corroborated. The discrepancies between the theoretical and experimental values of the energy transmitted are attributable (1) to the fact that transmitter and receiver are not placed on perfectly conducting ground, and (2) to an absorption of energy by the intervening landscape. The absorption of energy is the

same for damped and undamped waves, and increases strongly with decreasing wave-length. The absorption amounted to 57 per cent. in transmitting a 2000-m. wave from Cologne, 58.7 per cent. from Neumünster, and 54 per cent. from Strassburg, where the Rhine favours transmission. On mounting a single wire 87 m. in effective height at Göttingen, a sending current of 15 amps. at Cologne gave a received current of 4.84×10^{-4} amp. at Göttingen. The value calculated on the basis of previous results was 4.2×10^{-4} . E. E. F.

535. *The Theory of Oscillation Circuits.* N. Bulgakov. Acad. Sci. St. Pétersbourg, Bull. 2. pp. 125-182, Feb. 1, 1914.)—The important case when there is a spark-gap in the secondary is discussed. The resistance of the secondary circuit is supposed to be of the form $R/(1 - at)$, so that R is its resistance at time 0, and its resistance at time $1/a$ is infinite. The complete mathematical solution of the equation is obtained. A. R.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

536. *Thermal and Electric Peculiarities of Bismuth and Antimony Alloys.* G. Gehlhoff and F. Neumeier. (Deutsch. Phys. Gesell., Verh. 15. 17. pp. 876-896, Sept. 15, 1918.)—The thermal and electric conductivity as well as the thermo-e.m.f. of alloys of Bi and Sb were investigated between -190° and $+100^\circ$ C. The method of measurement of the thermal conductivity was similar to that adopted by C. H. Lees [Abstract No. 1677 (1908)]. As the percentage of Bi decreases from 100 % and that of Sb increases, the conductivity for heat at first decreases and then rises steadily till the material consists entirely of Sb. The explanation of Koenigsberger seems probable, viz. that in heat conduction in contradistinction to electric conductivity, besides the electrons the ponderable molecules also take part, and that the law of Wiedemann and Franz depends only on the process which is due to the behaviour of the electrons. The view of Kurbatow that the condition as to conductivity is only constant for each group of metals in Mendelejeff's system must be regarded as disproved by the results obtained by the authors. The quotient Λ/KT of the law of Lorentz shows, for the single alloys corresponding with the pure components, from the temperature of liquid air and upwards a decrease, and afterwards an increase in value. The capacity of heat for alloys which exhibit a solid solution, appears, from the observations made, to be a strongly additive quality as has been already stated by Saposchnikow. J. J. S.

537. *Electrical Conductivity of Anisotropic Liquids in Magnetic and Electric Fields.* T. Svedberg. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 9. pp. 1-15, 1918.)—The electrical conductivity of anisaldazine is influenced distinctly by a magnetic field up to 4850 gauss. If the magnetic field is longitudinal and of increasing strength there is at first a slow and then a rapid increase of conductivity, followed by a further slow increase which is roughly proportional to the strength of the field. In a transverse field the alterations are nil when small voltages are used to measure the conductivity, but under larger voltages the transverse magnetic field produces effects similar to those of the longitudinal field, although opposite in sign; if the voltages are above 20, the effects are almost equal and opposite. These effects are limited to the range, 166 to 177° C., of the anisotropic-liquid state. In the anisotropic state the current increases more rapidly than the voltage. On passing to the isotropic state the conductivity at low voltages increases, whilst that at high voltages decreases. T. M. L.

538. Dielectric Constant of Hydrogen at High Pressures. A. Occhialini. (Accad. Lincei, Atti, 22. pp. 482-484, Nov. 28, 1918.)—The methods previously described [see Abstracts Nos. 589, 1048, and 1496 (1918)] have been used to measure the dielectric constants, K , and the densities, d , referred to that at normal temperature and pressure, of hydrogen under various pressures. The results are as follows, the values in the three last columns referring to a temperature of about 24° .

Pressure (approx.) in Atmos.	d	K	$\frac{K-1}{d} \times 10^7$	$\frac{K-1}{K+2} \cdot \frac{1}{d} \times 10^6$
94	80	1.02180	2735	9018
117	100	1.02780	2780	9018
144	120	1.08280	2783	9012
169	140	1.08885	2789	9015
196	160	1.04890	2744	9014

Extrapolation gives the value 1.0002705 for K under atmospheric pressure, Tangl [see Abstract No. 1148 (1908)] having found 1.000278. The mean value for $(K-1)/(K+2)d$ is 90154×10^{-6} , the value obtained by Tangl for measurements at 20-100 atmos. being 908×10^{-7} ($898-908 \times 10^{-7}$). T. H. P.

539. Dielectric Constant of Nitrogen at High Pressure. E. Bodareu. (Accad. Lincei, Atti, 22. pp. 480-482, Nov. 28, 1918.)—By the methods previously described [see Abstracts Nos. 589, 1048, and 1496 (1918)] the author has measured the dielectric constants, k , and densities, d , of nitrogen at high pressures, the mean results being as follows :—

Pressure (approx.) in Atmos.	d	k	$\frac{k-1}{d} \times 10^7$	$\frac{k-1}{k+2} \cdot \frac{1}{d} \times 10^7$
87	80	1.04750	5988	1949
114	105	1.06276	5978	1952
148	180	1.07828	6022	1956
174	155	1.09878	6047	1955
205	180	1.10958	6085	1957
226	195	1.11867	6086	1952

The values in the last two columns correspond with a temperature of about 28° . The densities are referred to that of nitrogen at 0° and 760 mm., and the pressures are calculated from Amagat's table. Tangl [see Abstract No. 1148 (1908)] found the values 1935 for $(k-1)10^7/(k+2)d$ and 1.000581 for the dielectric constant at 1 atmo. pressure, while the number 1.000587 is obtained by extrapolation from the author's results. T. H. P.

540. The Thermal Coefficient of Contact E.M.F. H. C. Burbridge. (Phys. Rev. 2. Ser. 2. pp. 188-197, Sept., 1918.)—Experiments were made on the change produced in the contact p.d. when change of temperature occurs. A Dolezalek electrometer and a condenser consisting of sliding cylinders were employed. Copper, Ni, Zn, Sn, and Al were investigated, and oxidation effects were noticeable which have to be allowed for in estimating the change

due to rise of temperature. Further experiments on other metals and with a wider range of temperature may be carried out later. The values for the coefficient are given in the following table :—

Metal.	Temp. Range.	Coeffit., Volts per deg.
Cu	20 to 70°	0·00050
Ni	20 to 90°	0·00086
Zn	20 to 55°	0·0024
Sn	20 to 45°	0·00096
Sn	45 to 90°	0·0020
Al	20 to 40°	0·0011
Al	40 to 70°	0·0028
Al	70 to 90°	0·0086

J. J. S.

541. On the Self-inductance of Circular Coils of Rectangular Section. T. R. Lyle. (Roy. Soc., Phil. Trans. 218. pp. 421-485, Jan. 81, 1914.)—Maxwell gave the formula $L = 4\pi an^2[\log_e(8a/r) - 2]$ for the self-inductance of a coil of rectangular section, where a is the mean radius and r the geometric mean distance of the section of the coil from itself; the current being supposed to be uniformly distributed over the section. The author shows that the same formula will give the self-inductance to any order of accuracy when in it are substituted for a and r the mean radius and the G.M.D. respectively, each suitably modified by small quantities which depend on a and on the section of the coil. Tables are given by means of which the modified values of a and r for any coil of rectangular section can be found. These values when substituted in the above formula give L correct to the fourth order, uniform current density over the section being assumed.

A. R.

542. Experiments on Potential Difference. S. Magrini. (N. Cimento, 6. Ser. 6. pp. 178-178, Sept., 1918.)—The experimental arrangement is described, by which the p.d.'s between various points of a uniform wire, in which a steady current is flowing, are indicated by capillary electrometers of the horizontal type. The p.d.'s are proportional to lengths of wire, and, therefore, to the resistances between the points considered. A modification is also given, in which the electrometers are joined electrolytically to two points in the interior of a cell. This is formed of a U-tube with the electrometer tubes sealed into its limbs, the electrodes being situated at the upper ends of the limbs. The p.d.'s within the cell are as would be expected, both when the current is flowing and when it is not.

S. G. S.

543. Lag and Lead demonstrated with a Braun Tube. J. F. Mohler. (Science, 89. p. 210, Feb. 6, 1914.)—Describes a new method of illustrating the lag and lead in an alternating-current circuit due to inductance or capacity. A Braun tube is excited by an induction coil with its vibrator adjusted to a period which is nearly a multiple of that of an alternating current flowing in two solenoidal circuits. These solenoids are placed with their axes perpendicular to each other and to the axis of the tube. The stroboscopic effect then causes the spot of light on the screen to move slowly back and forth in a straight line until a considerable inductance or capacity is

introduced into one of the solenoidal circuits, whereupon the spot describes an ellipse varying in width according to the amount of the inductance or capacity introduced.

J. W. T. W.

544. *Electrometry with the Displacement Interferometer.* C. Barus. (Amer. Journ. Sci. 37. pp. 65-86, Jan., 1914. Abstract from Report to Carnegie Inst. of Washington.)—Examines the sensitiveness of various forms of absolute electrometer, the motion of the movable conductor being measured by means of a displacement interferometer. Three forms of electrometer were used: (i) and (ii) concentric cylinders with the movable cylinder within and without respectively, and (iii) parallel discs. In every case a bifilar suspension was used for the movable conductor. Equations are theoretically deduced for these cases and for that of a closed-field electrometer (discs and cylinder combined). The experimentally determined voltages in cases (i) and (ii) are in close agreement with voltmeter readings, but the greatest sensitiveness obtainable was by no means that to be expected from the formulæ, being of the order of 0.06 volt per ring (of the interferometer). In case (iii), with the movable disc placed symmetrically between the fixed ones, the voltage found from the formula is a slightly varying multiple of that given by the voltmeter. This multiple was made more constant by giving the disc a certain degree of asymmetry determined from experiments on a known voltage. The sensitiveness is greater than that of the cylindrical forms, but is still not sufficiently great to be immediately valuable for refined practical measurements. Experiments were also made with an ordinary quadrant electrometer so modified as to render the motion of the needle measurable by the interferometer. A sensitiveness of 10^{-6} volt per ring was obtained.

J. W. T. W.

545. *Contribution to Theory of String Galvanometer.* J. K. A. W. Salomonson. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 522-589, Dec. 27, 1918.)—Stefan showed (Wied. Ann. 1889) that, in an electromagnet, the field in the interpolar space would be increased by giving the pole-pieces a conical form with a top angle of about 110° . In the string galvanometer, prismatic pole-pieces are used, and it is shown that about the same value holds for the top angle of such poles. When a constant current is passed through the string, the latter assumes catenary form, and if the field is constant over the length of the string the curve is parabolic. Particulars are given of the exploration of the field of an Einthoven galvanometer magnet by means of a Cotton balance and a bismuth spiral. Finally, an expression is found by two methods, for the "active" field strength of the magnet, viz. $H = 82N^{\frac{1}{2}}h\pi r^2 g I$, where N is the frequency of the wire, h its lateral displacement, r its radius, and I the current in it.

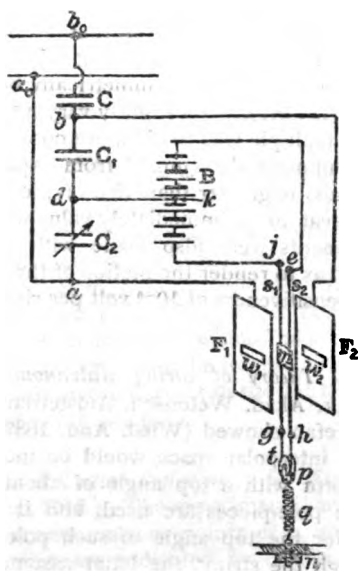
G. E. A.

546. *The Vibration Electrometer.* H. Greinacher. (Elektrotechn. Zeitschr. 34. pp. 1485-1486, Dec. 25, 1918.)—In continuation of his work on the use of the Wulf electrometer for alternating-current bridge tests [see Abstract No. 1579 (1912)] the author now shows how it may be used in connection with measurements of electrical and magnetic fields. Thus for measurements in the former case a simple wireless system is used in which the sender and receiver are upright metal rods. On exciting the transmitter the receiver, which is connected directly to the fibres of the electrometer, causes the fibres to be thrown into vibration. The vibration can be increased by introducing between the sender and receiver a slab of some dielectric. Thus the

apparatus is suitable for the measurement of the dielectric constant. A disadvantage of the use of such an instrument for alternating work is that the platinum soon peels off the quartz fibre. The author has therefore constructed a special vibration electrometer in which he uses a Pt-wire of thickness 5μ as the vibrator; a description of the instrument is given in the original.

W. C. S. P.

547. An Electrostatic Oscillograph. H. Ho and S. Koto. (Phys. Soc., Proc. 26. pp. 16-26; Discussion, pp. 26-27, Dec., 1918. Electrician, 72. pp. 290-291, Nov. 21, 1918. Abstract. Electrical World, 62. p. 1840, Dec. 27, 1918. Abstract.)—The voltage to be measured between a_0 b_0 is applied to two parallel metallic field-plates F_1 , F_2 . C is an oil condenser to be used, if necessary, for reducing the said voltage to a suitable value at the terminals a , b of the oscillograph. Two bronze strips s_1 , s_2 are stretched



between the field plates and are parallel to one another and the plates and carry a mirror m ; the tension can be adjusted in the usual way. The two strips are insulated from each other by silk thread t which passes over an ivory pulley p , thus forming two electrically independent conductors. w_1 is an opening for the passage of light to the mirror, w_2 being a similar one in F_2 in order to maintain the symmetry of the electric field. The plates and strips mounted on an ebonite frame are immersed in an oil bath. The oil not only acts as a damping agent but increases the sensitiveness owing to its high dielectric constant. In parallel with the field plates are the oil condensers C_1 , C_2 , the latter being adjustable. The mid point of a battery B of small cells (800 volts) is connected to d and its terminals are connected to the strips to charge them, just as the needle of a quadrant electrometer is charged. The turning moment on the strips is proportional to the product of the momentary values of the alternating-current voltage and the direct-current voltage. With this arrangement voltages up to 9000 have been measured. The sensitiveness is such that for an effective voltage between

field plates of 2000 and a battery of e.m.f. 800 volts a wave of 2 cm. amplitude was obtained at a distance of 70 cm., when the vibrator was adjusted to its natural period of $1/8800$ sec. In working with an electromagnetic oscillograph at high voltages using a "non-inductive" resistance in series with the latter vibrator there is a decided capacity current. This is brought out clearly by means of two curves obtained by working the electrostatic and electromagnetic vibrators in parallel. In cases where the voltage is low but the source of energy is so limited that sufficient current cannot be taken to actuate an ordinary oscillograph, the electrostatic vibrator may be used by applying the voltage to the strips while the terminals of a high-tension battery or influence machine are connected to the field plates. Very small currents may also be recorded by replacing the oil condensers by two exactly equal resistances which are traversed by the current.

The instrument is now constructed by the Cambridge Scientific Instrument Co. W. C. S. P.

548. Mercury Lamp. Billon-Daguerre, L. Medard, and H. Fontainé. (*Comptes Rendus*, 157. pp. 921-922, Nov. 17, 1918.)—Describes a new form of water-cooled mercury lamp, giving practically cold light. The lamp is composed principally of a cylindrical or flat tube of inverted U-form, the ends being curved up again to carry the tubes for the electrodes. This U-tube is placed inside a flask of special form with a long vertical neck closed by a ground stopper. The whole is of fused quartz, pure and transparent; the electrodes are of invar. The wall of the flask on the side opposite to that to be used for light has the form of a paraboloid and can be silvered to form a reflector for concentrating the light. The whole is immersed in a bath of water. The lamp will take a current of 18 amps. with 70 volts across its terminals. Various advantages and applications are noted. A. W.

549. Electrometer of High Sensitiveness. G. Hoffmann. (*Ann. d. Physik*, 42. 6. pp. 1196-1220, Dec. 28, 1918.)—A paper giving further details and theory of the author's sensitive electrometer previously described. [See Abstracts Nos. 1488 (1912) and 609 (1918).] A. W.

ALTERNATING CURRENTS AND MAGNETISM.

550. Alternating Magnetisation at High Frequencies. C. E. Guye and [Miss] A. Albert. (*Archives des Sciences*, 87. pp. 20-86, Jan., 1914.)—The current from an alternator was passed through the primary wound on a torus of fine iron wire, and the effective e.m.f. in the secondary was measured by means of an electrostatic voltmeter. Frequencies (n) of 1200, 600 and 300 were employed in conjunction with secondary windings numbering N , where N varied in the ratio 1:2:4, so that the product nN was constant. The combined results show that the rapidity of variation of the magnetic field has no appreciable effect on the magnetisation curve. The fields varied between 8 and 25 gauss. G. E. A.

551. Measurement of Magnetic Fields. P. E. Klopsteg. (*Phys. Rev.* 2. Ser. 2. pp. 890-899, Nov., 1918.)—The method described depends on the damping effect of the field on a vibrating coil. An expression for the field strength is derived from the equation to a damped simple harmonic motion, in terms of the logarithmic decrements of the coil with closed and open circuits respectively. The case for which the coil is critically damped, i.e. becomes aperiodic in its motion, is also worked out. The equations are
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verified experimentally, and an accuracy of 1 per cent. is obtained for the determination of H from the periodic motion, for fields of 1 to 1500 c.g.s. [See also Abstract No. 1446 (1908).] G. E. A.

552. Magnetisation of Iron at Low Inductions. L. W. Wild. (Inst. Elect. Engin., Journ. 52. pp. 96-105, Dec. 15, 1918.)—A description of tests carried out on samples of lohys (mild steel) and stalloy (silicon steel) transformer steels, built up into magnetic squares. Both direct and alternating currents were used; with the former, B was given by means of a ballistic galvanometer, and with the latter, B was measured with a combination of rectifier and calibrated galvanometer. The experiments led to the following conclusions:—Subjecting the iron to demagnetising treatment has a kind of loosening effect on the molecular magnets, so that directly afterwards reversing the magnetising force leads to an abnormal change of flux and an abnormally high permeability. The effect wears off in about 48 hours. At flux densities between 1 and 100, the process of demagnetisation is so slow that no ordinary ballistic galvanometer can include the whole change of flux on reversal of the magnetising force. When the reversal of force is divided into two parts, the change of flux takes place even more slowly than on a simple reversal, so that attempts to measure the hysteresis loss ballistically are likely to be very misleading. Permeability on alternating current is sensibly the same at 50 as at 25 \sim . Ballistic permeability is higher, and true continuous-current permeability the highest of all. The hysteretic index is about 8 on alternating current between $B_{\max.} = 1$ and $B_{\max.} = 10$. Above the latter figure the index declines, but is still above 2 at $B_{\max.} = 100$. On alternating current, hysteresis loss is present down to $B_{\max.} = 0$, although no retentiveness could be detected below $B_{\max.} = 1$ on ballistic tests. [See also Abstract No. 1208 (1918).] G. E. A.

553. Relation of the Specific Heats and Melting-points of certain Alloys to their previous Thermal History and, in the case of Heusler Alloys, to their Magnetic Properties. E. Dippel. (Ann. d. Physik, 42. 5. pp. 889-902, Dec. 2, 1918. Extract of Dissertation, Marburg.)—Heusler discovered that in certain malleable copper-rich Al bronzes hysteresis can be developed to a greater or lesser extent by suitable heat-treatment. These qualitative observations were subsequently confirmed quantitatively by Asteroth [Abstract No. 688 (1908)], who showed that the hysteresis is always greater in slowly cooled and aged alloys than in quenched and aged alloys. Richarz concluded that slow cooling aids, and quenching prevents, the formation of complex molecular aggregates. Now if this view be correct certain alloys should show lower specific heats when slowly cooled than when rapidly cooled, since the formation of a complex diminishes the molecular freedom in the kinetic sense and so causes a lowering of the specific heat. Experiments with an alloy of 98 % Pb and 7 % Bi showed that slowly cooled samples actually possessed a lower specific heat than rapidly cooled samples. It was also found that the melting-point of this alloy could be varied between 801.5° C. and 805° C. according to the thermal treatment it had received. Experiments were also made with a Heusler alloy containing 14.25 % Mn, 10.15 % Al, small quantities of Fe and the residue Cu. Two samples were forged, annealed, quenched, and aged. The specific heat of the slowly cooled alloy was found to be appreciably lower than the quenched alloy. Short ageing slightly increases, but prolonged ageing decreases, the specific heat. These phenomena are discussed in relation to the magnetic phenomena observed by Take. F. C. A. H. L.

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554. Longitudinal Thermomagnetic Potential-difference. A. W. Smith. (Phys. Rev. 2. Ser. 2, pp. 888-889, Nov., 1913.)—When a plate along which heat is flowing is subjected to a transverse magnetic field, the p.d. between two points on the length of the plate is increased or diminished by the amount $\epsilon = L \cdot H(t_1 - t_2)$, where H is the field, $t_1 - t_2$ the temperature difference, and L the coefficient of the effect. Zahn found L to increase with rise of temperature [see Abstract No. 8268 (1904)]. The author finds that his result is not in agreement with the observations of Zahn. The potential gradient set up by the magnetic action is in the opposite direction to the temperature gradient of the plate, and the value of L diminishes with rise of temperature, probably vanishing at the melting-point of Bi. The value of L found for 58°C. was 0.102 in a field of 9600 c.g.s., which agrees well with Barlow's value of 0.100 in a field of 11,000. The effect in graphite is positive and much smaller than in bismuth. The effect in monel metal, an alloy of Ni, Cu, Fe, and Mn, is also positive. In the case of Bi-Sb alloys, the effect is greatest when the alloy contains about 9 per cent. of Sb. [See also Abstract No. 79 (1912).] G. E. A.

555. Magnetic Field of Two Electromagnets in Rotation. S. J. Barnett. (Phil. Mag. 26, pp. 987-991, Dec., 1918.)—For these experiments two similar cylindrical electromagnets were mounted with their axes in the same straight line, and were so magnetised that the lines of induction stretched across from one of the adjacent poles to the other. A small elongated cylinder of iron was so mounted at the point of the field under investigation as always to follow any change (of the sort under test) in the direction of the intensity at the point, and a mirror attached to the magnet's support and other optical appliances made it possible to determine any change in the magnet's orientation with great precision. The magnets were driven at about 80 revs. per sec., and the field was about 1200 gauss. The change in direction of a line of the field owing to this rotation was very small, the mean value observed being about one second of arc. [See Abstract No. 115 (1914).] E. H. B.

556. Theory of Thermomagnetic Effects. H. Zahn. (Phys. Zeitschr. 14, pp. 926-928, Oct. 1, 1918.)—In view of the difficulties attending the electron theories of the thermomagnetic effects in metals, the author advances a new explanation based upon the "bound" electrons. These, when revolving in the plane perpendicular to the magnetic field, may be taken to represent two equal and opposite currents which as a rule are accurately compensated. Any difference of temperature along the plate produces a difference in the density of free electrons, and the resulting current exerts opposite forces upon the two quasi-currents referred to, this producing a lateral component of the e.m.f. The author does not formulate this theory analytically, and anticipates some difficulty in doing so. E. E. F.

557. The Molecular Field and a Law of Action inversely as the Sixth Power of the Distance. P. Weiss. (Comptes Rendus, 157, pp. 1405-1408, Dec. 22, 1913.)—The molecular field imagined by the author to render ferromagnetic phenomena accessible to the kinetic theory is defined by the expression, $H_m = N \cdot I = N \cdot D \cdot \sigma$, where I is the intensity of magnetisation, N the constant of the molecular field, D the density, and σ the specific magnetisation. Although this has proved itself a fertile hypothesis, yet it is impossible to conceive of this molecular field as a true magnetic field; the forces may indeed be of any nature whatsoever. Investigation of a substance formed of given

molecules of all densities should give the law of variation with the distance of the actions producing the molecular field. This question is resolved, at least in a particular case, by means of alloys of the ferromagnetic metals. With the systems iron-cobalt, iron-nickel, and nickel-cobalt the variation of the coefficient N with the composition is either linear or distinctly non-linear, the former being probably characteristic of metals of unlimited reciprocal solubility. Where one of the metals is magnetically neutral and serves merely to dilute the other, the coefficient N is proportional to the density of the magnetic metal in the alloy, and hence the molecular field, H_m , for a given specific magnetisation, is proportional to the square of the density. This variation of density may be obtained by amplifying all the distances in a ratio λ . The molecular field, multiplied by λ^{-6} , is a homogeneous function of the minus sixth degree of the distance. If the elementary action of a molecule on a neighbouring molecule be regarded as developed in a series according to the powers of the distance, either the sixth power must exist alone or the other powers must disappear in the summation extended to the sphere of molecular action. The law of action thus found shows that the molecular field is neither magnetic nor electrostatic, and that it is produced by molecular actions of new type and unknown character.

T. H. P.

558. *Electromagnetic Fields in Ferromagnetic Metals.* W. Arkadief. (Phys. Zeitschr. 14. pp. 928-984, Oct. 1, 1918.)—This is a sketch of a theory of electromagnetic actions in ferromagnetic metals according to the usual electromagnetic theory of dispersion. It yields a value for the proper periods and diameters of the elementary magnets and of the "magnetic conductivity." The wave-length of the proper oscillation, derived from the change of absorption of parallel wires with change of electromagnetic wave-length, is 5.9 cm. in the case of Fe, and 7.8 cm. in the case of Ni. The corresponding proper periods are 1.97×10^{-10} and 2.48×10^{-10} sec. respectively. The radii of the elementary magnets are 9.4×10^{-9} cm. for iron and 8.8×10^{-9} cm. for Ni (neglecting the crystalline structure of the metals). The viscosity appears to be about 1.4×10^{-5} , which is of the same order as that of gases, thus recalling the applicability of the theory of Langevin's gases to ferromagnetic bodies, as shown by Weiss.

E. E. F.

559. *Magnetic Properties of the Alkaline Metals in Combination.* P. Pascal. (Comptes Rendus, 168. pp. 87-89, Jan. 5, 1914.)—The additivity of diamagnetic properties, which has been established for organic compounds, can only be generalised in mineral chemistry in certain series of metals, the group of the alkaline metals being the most outstanding in this respect. The case of the elementary bodies is doubtful, since it is difficult to obtain the metals in a pure state free from iron. Their salts can, however, be obtained in the pure state, and these bodies exhibit strongly diamagnetic behaviour. The coefficient of molecular magnetisation was determined for seven different salts of the alkaline metals, and, that of the acid radical being known, the coefficient of atomic magnetisation was found by subtraction. The mean coefficients thus obtained were Li, 4.2; Na, 9.2; K, 18.5; Rb, 27.2; Cs, 41.0 (all multiplied by -10^{-6}).

G. E. A.

560. *Magnetic Susceptibility of Paramagnetic Salts in Solution.* A. Heydweiller. (Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1120-1122, Nov. 15, 1918.)—Measurements of the magnetic susceptibility of ferric chloride, manganous sulphate and nitrate, nickel nitrate, chromic sulphate

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and nitrate, and cobalt nitrate in aqueous solutions show that the molecular susceptibility possesses a max. value at a certain concentration dependent on the nature of the dissolved salt. Further, ferric chloride and manganous sulphate and nitrate exhibit also minimal values at lower concentrations. Like most other properties, the magnetic susceptibility is presumably dependent on the degree of dissociation and increases with this. Starting with the greatest dilutions, increasing concentration is accompanied by diminution of the susceptibility, and this change the author regards as opposed by the formation of magnetic chains analogous to those of Grotthus, by means of which the susceptibility is increased. The subsequent diminution in the susceptibility is attributed to the formation of complexes, that is, of astatic ring systems.

T. H. P.

561. *Magneto-chemistry of Iron Compounds and the Magneton Theory.* B. Cabrera and E. Moles. (Archives des Sciences, 86. pp. 502-518, Nov., 1918.)—Using an improved apparatus, the authors have continued their earlier investigations [see Abstract No. 1519 (1918)]. With aqueous ferric sulphate solutions, the number of magnetons tends to approach the value 27 as the concentration of the salt increases. When the hydrolysis of the salt is diminished by the addition of gradually increasing proportions of sulphuric acid the number of magnetons approaches more and more nearly to 29. This result agrees with the observation that the hydrogen ion restores the molecule to its original condition, the number of magnetons then approaching 29 (*loc. cit.*). The molecular susceptibility of potassium ferrocyanide is practically independent of its concentration. After being heated for 15 minutes at 80°, M/10-, M/20-, and M/40-solutions of ferric chloride exhibit diminished susceptibilities, the extent of the diminution, like the hydrolysis, being the greatest for the most dilute solution.

T. H. P.

562. *Coefficient of Magnetisation of Nitric Oxide and the Magneton.* P. Weiss and A. Piccard. (Comptes Rendus, 157. pp. 916-918, Nov. 17, 1918.)—By means of a modification of the method previously employed [see Abstract No. 518 (1918)], the authors have measured the molecular coefficient of magnetisation of nitric oxide at 20°, the value found being $\chi_m = 1400.8 \times 10^{-6}$. The number of magnetons per molecule is calculated to be 9.089, which differs from the integer by less than the experimental error of the measurements.

T. H. P.

563. *Determination of Horizontal Intensity of Earth's Magnetic Field.* W. A. Jenkins. (Phil. Mag. 26. pp. 752-774, Oct., 1918.)—A new method is proposed for determining the horizontal intensity of the earth's magnetic field, the principle being to produce a known field opposite in direction to that of the earth and twice its value. The equality of the two fields, that due to the earth alone and that due to the combination, is determined by the equality of the times of vibration of the same magnet when the applied field is off and on, and the strength of the applied field is then determined by measuring the current producing it. Many of the corrections necessary to the ordinary magnetometer method may be eliminated, and the procedure thereby considerably shortened and simplified. Details are given of the construction of the helix, and magnet, with results of observations made at Sheffield. These confirm the claim that the new method gives values reliable to the fourth figure.

C. P. B.

RADIOLOGY AND ELECTROPHYSIOLOGY.

584. Powerful Röntgen-ray Tube with a Pure Electron Discharge. W. D. Coolidge. (Phys. Rev. 2. Ser. 2. pp. 409-480, Dec., 1918. Electrical World, 68. pp. 220-221, Jan. 24, 1914. Abstract. Gen. Elect. Rev. 17. pp. 104-111, Feb., 1914.)—A new and powerful Röntgen-ray tube is described in detail. It differs in principle from the ordinary type in that the discharge current is purely thermionic in character. Both the tube and the electrodes are as thoroughly freed from gas as possible, and all the characteristics seem to indicate that positive ions play no appreciable rôle. The pressure, instead of being, as in the ordinary tube, a few microns (thousandths of a millimetre), is as low as it has been possible to make it, that is, not more than a few hundredths of a micron (*i.e.* a few hundred-thousandths of a mm.). The cathode consists of a body, which can be electrically heated (such as a tungsten or tantalum filament) and, suitably located with reference to this portion, an electrically conducting ring or cylinder, consisting preferably of molybdenum or tungsten or other refractory metal. The ring or cylinder is connected either to the heated portion of the cathode or to an external source of current, by means of which its potential may be brought to any desired value with respect to the heated portion. The heated portion of the cathode serves as the source of electrons, while the ring or cylinder assists in so shaping the electrical field in the neighbourhood of the cathode that the desired degree of focusing of the cathode-ray stream upon the target shall result. The antikathode, or target, functions at the same time as anode. The tube allows current to pass in only one direction and can therefore be operated from either direct or alternating current. The intensity and the penetrating power of the Röntgen rays produced are both under the complete control of the operator, and each can be instantly increased or decreased independently of the other. The tube can be operated continuously for hours, with either high- or low-discharge currents, without showing an appreciable change in either the intensity or the penetrating power of the resulting radiations. The tube in operation shows no fluorescence of the glass and no local heating of the anterior hemisphere. The starting and running voltage are the same. The tube permits of the realisation of intense homogeneous primary Röntgen rays of any desired penetrating power.

A. E. G.

585. Cancer and Secondary Rays from Calcium Phosphate. R. A. Fessenden. (Elect. Rev. and West. Electn. 68. p. 1267, Dec. 27, 1918.)—The author has accumulated a considerable amount of evidence to the effect that when cancer has been cured by radium, the effect has been due to secondary radiations from one of the constituents of bone material.

E. M.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

566. Molecular Structure of Liquid Crystals. J. S. van der Lingen. (Deutsch. Phys. Gesell., Verh. 15. 19. pp. 918-918, Oct. 15, 1918.)—When examined by the Röntgen-ray method of Laue, liquid-crystalline layers of *p*-azoxyanisol and *p*-azoxyphenetol do not give any indications of space-lattices. T. M. L.

567. Intra-atomic Charge. A. van den Broek. (Nature, 92. pp. 872-878, Nov. 27, 1918.)—According to Rutherford [Abstract No. 1847 (1911)] an atom consists of a very concentrated central nucleus of positive electricity surrounded by negative electrons distributed throughout the remainder of the atom. In the case of the scattering of α -particles by such a nucleus the ratio of the amount of scattering per atom divided by the square of the charge on the nucleus must be constant. Geiger and Marsden, however [Abstract No. 1296 (1918)], putting the nuclear charge proportional to the atomic weight, found values for the ratio, showing, not quite constancy, but systematic variation from 8.82 for Cu to 8.25 for Au. If now in these values the number *M* of the place in Mendeleeff's series (Cu = 29, Ag = 47, Sn = 50, Pt = 82, Au = 88) instead of *A*, the atomic weight be taken, a real constant is obtained. Hence the nuclear charge of an atom is not equal to half the atomic weight but to its place number in the periodic table. Should thus the mass of the atom consist for by far the greatest part of α -particles, then the nucleus too must contain electrons to compensate this extra charge. E. M.

568. Intra-atomic Charge. F. Soddy. (Nature, 92. pp. 399-400, Dec. 4, 1918.)—The author considers that recent generalisations as to the radio-elements and the periodic law [Abstract No. 170 (1914), etc.] support the conclusion of van den Broek [see preceding Abstract], that the intra-atomic charge of an atom is determined by its place in the periodic table rather than by its atomic weight. Thus the successive expulsion of one α - and two β -particles in three radio-active changes, in any order, brings the intra-atomic charge of the element back to its initial value, and the element back to its original place in the periodic table. On Rutherford's theory this is equivalent to assuming that the positive charge on the nucleus is the difference between a positive and a smaller negative charge.

If β -particles expelled in radio-active transformation do not come from the "nucleus" but from the same region of the atom as the electrons concerned in ordinary chemical changes, then the author deduces, as follows, that Ur in its tetravalent compounds ought to be non-separable from thorium compounds: UrX, formed from UrI by expulsion of an α -particle, is chemically identical with, and non-separable from, thorium compounds [Abstract No. 170 (1914)], as also is ionium formed in the same way from UrII. UrX loses two β -particles and passes back into UrII chemically identical with UrI. Uranous salts also lose two electrons and pass into the more common hexavalent uranyl compounds. Thus if these electrons come from the same region of the atom uranous salts should be chemically non-separable from thorium salts. Fleck has shown that this is not the case, and the author therefore considers this as a proof that β -particles come from the nucleus. E. M.

569. *Intra-atomic Charge and the Structure of the Atom.* A. van den Broek. (Nature, 92. pp. 476-478, Dec. 25, 1918.)—The paper discusses the nature of the nucleus of an atom and the question as to whether its algebraic positive charge is the atomic number or the place in Mendelejeff's table [see preceding Abstract and next Abstract]. A condensed periodic table is suggested and considerations are given of the connection between the atomic weight of an atom A, its place in Mendelejeff's table M, its place in the condensed table P, and the number of electrons in the nucleus, kP^2 ($k = \text{a constant}$). It is shown that $A - 2M = kP^2$. It is also shown that Whiddington's relation for the velocity v of a cathode particle required to excite the characteristic radiation in an atom, holds better for $v \propto M$ than for $v \propto A$.

It is possible that a cluster of α -particles may be at the centre of an atom with some rings of electrons of a diam. smaller than 8×10^{-13} cm. These rings may have no influence at all on the properties of the elements and for an electron penetrating from without will belong to the nucleus, while for an electron ejected from the innermost ring they will not. So the characteristic radiation will depend on M and not on A, since an electron penetrating the atom must pass through the region of M electrons, to excite, if it is of the right velocity, the outer rings of what, from a chemical point of view, might be called the nucleus. But a β -particle ejected from the innermost ring must pass all other rings and excite radiation different for each ring and for each "isotope." [See Soddy, Abstract No. 170 (1914).] E. M.

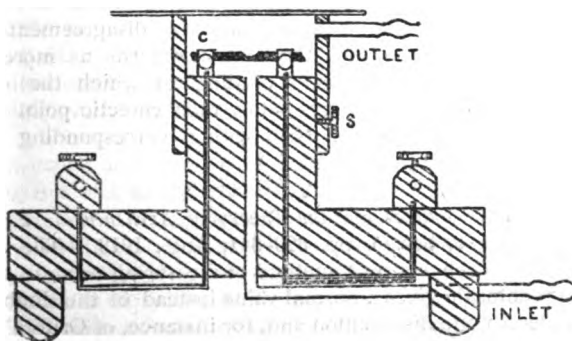
570. *Structure of the Atom.* E. Rutherford. (Nature, 92. p. 428, Dec. 11, 1918.)—The paper contains a discussion of the nature of the charge on the "nucleus" of an atom [see Abstract No. 1847 (1911)] and the question as to whether β -particles originate from it or from the external electrons. The strongest evidence in support of the former view is (1) β -ray, like α -ray, transformations are independent of physical and chemical conditions; (2) the energy emitted in the form of β - and γ -rays by the transformation of an atom of RaC is much greater than could be expected to be stored up in the external electronic system. At the same time the author considers it probable that a considerable fraction of the β -rays which are expelled from radio-active substances arise from the external electrons. This, however, is probably a secondary effect resulting from the primary expulsion of a β -particle from the nucleus. It would appear that the algebraic positive charge on the nucleus is the fundamental constant which determines the physical and chemical properties of the atom, while the atomic weight, although it approximately follows the order of the nucleus charge, is probably a complicated function of the latter depending on the detailed structure of the nucleus. E. M.

571. *Decompositions by Ultra-violet Light (Organic Compounds, Metallic Iodides).* A. Kallan. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 751-786, April, 1918.)—In the case of organic acids the author merely determines, by means of titration with alkali, the proportion of decomposed acid. Of these, acetic acid showed most, and oxalic acid least decomposition, and the introduction of the hydroxyl group increased the rate of decomposition. Quartz vessels were used; no decomposition was observed in glass vessels. The oxygen absorbed from the air did not seem to be concerned in these reactions, since evacuation of the acid solutions made no difference. The rotation of fermentation amyl alcohol was not affected by $8\frac{1}{2}$ hours of radiation, although some acid and some water were formed. The iodides of Ba and Sr were more rapidly

decomposed than those of the alkalis, but this held only for neutral, not for acid solutions ; one addition of 1/800 mol. per litre of HCl increased the rate of decomposition, but further addition of acid had no effect. Intermittent radiations proved relatively more powerful than continuous radiation ~~as~~ to the effect of atmospheric oxygen ; with evacuation before subjection to the radiation the effects were diminished by one-half. The presence of thiosulphate, of acid, of primarily formed H_2O_2 , as well as heating, hardly affected the rate of decomposition. Aqueous solution of potassium fluoride was not decomposed in 2 hours. Reference is made chiefly to Berthelot and Gaudechon and to W. H. Ross. H. B.

572. Chemical Action of Penetrating Radium Rays. VI. Action on the Iodides of the Alkaline Earth Elements. A. Kailan. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 787-810, April, 1918.)—The experiments [see Abstracts Nos. 716 and 1741 (1918)] were made with neutral or acid (HCl) aqueous and alcoholic solutions of the iodides of Mg, Ca, Sr, Ba. The resulting decomposition was determined by means of thiosulphate. The iodides behaved on the whole like those of the alkalis ; no relation between the rapidity of the decomposition and the atomic weight could be found, yet the Sr and also the Ba salts were more readily decomposed than the alkali salts ; but the SrI₂ showed certain anomalies. The decomposition was more rapid in the case of the solutions in absolute alcohol of the MgI₂ than in the case of the aqueous solutions, neutral and acid. The action of the radium rays was of the same nature as that of ultra-violet rays ; but the effect of from 80 to 200 mgm. of the radium rays (calculated for the metallic Ra) was only 1/200 to 1/800th of the effect of the ultra-violet rays of a quartz mercury lamp at 8 cm. distance, and the ratios of the orders of magnitude differed. H. B.

573. Fractionation of Alloys and Minerals in the Electric Micro-furnace. A. L. Fletcher. (Chem. Soc., Journ. 108. pp. 2097-2108, Dec., 1918.)—The micro-furnace, which is illustrated by the accompanying diagram, consists of a brass drum sliding over a solid slate cylinder 5 to 8 cm. in diam., carrying terminals for a carbon rod which can be rapidly heated electrically to



extremely high temperatures. The cylinder is covered by a sheet of glass, fused silica or porcelain, and the enclosed space can be filled with various gases or partially exhausted. In application to qualitative analysis a small quantity of the material is placed in the depression, volatilised, and the deposit examined. Tables are given showing the colour of the deposits

obtained from a large number of metals in atmospheres of air, hydrogen sulphide, and iodine. Quantitative separations have also been made on a large number of alloys. The difficulties met with are (1) mechanical retention of the more volatile metal by the less volatile one, (2) the alloy (more particularly alloys of Al) does not assume the spherical condition, and (3) oxidation. In every case the residue and not the sublimate is weighed. As illustrative of the delicacy of detection of certain elements, it has been found that the zinc present in 0.0005 gm. of coinage bronze can readily be detected when distilled on to glass, the actual quantity being 5×10^{-4} gm. The method has also been applied to the rapid examination of such minerals as syvanite and psilomelane.

F. C. A. H. L.

574. Chemical Action of Penetrating Radium Rays. VII. Action on Dextrose, Alcohol, Organic Acids and Silver Nitrate. A. Kailan. (Akad. Wiss. Wien, Ber. 122, 2a, pp. 811-881, April, 1918.)—The rotation of 200 cm.³ of normal aqueous solution of dextrose was not visibly affected at 5° and 10° in 2860 hours by the radiations from 106 mgm. of RaCl₂; there was, however, some formation of acid, more than with sucrose, and more than would be accounted for by the action of any H₂O₂ formed. Absolute ethyl alcohol is oxidised to aldehyde and acid, and water is split off. Succinic and malonic acids are affected to a very slight degree, much less than by ultra-violet rays (similarly as with alkali iodides), and the electrolytic conductivity and dissociation seem to remain unchanged. The penetrating rays of 42 mgm. RaCl₂, acting for 4000 hours at from 8° to 8° C. in the dark on 5 gm. AgNO₃ in aqueous N/4 solution reduced about one-thousandth of the silver, which was deposited on the glass as a grey film; the solution remained neutral.

H. B.

575. Influence of Thermal Treatment on the Solidification and Transformation of Tin-Cadmium Alloys. D. Mazzotto. (N. Cimento, 6. Ser. 6. pp. 194-211, Sept., 1918.)—Further studies have now been made on these alloys [see Abstract No. 172 (1914)]. With tin-cadmium alloys, although the effects of thermal treatment are small, yet they occur in the sense and intensity to be expected from the form assumed by the melting-point diagram below the eutectic line and, more especially, from the variation of the solubility of Cd in Sn. None of the results obtained are in disagreement with the hypothesis of supersaturation, but the author regards as more probably correct the alternative hypothesis, according to which the exothermal phenomena manifested by these alloys below their eutectic point are caused by the transformation of γ -Sn in β -Sn, with a corresponding immediate separation of the dissolved Cd.

T. H. P.

576. Differential Ionometry and the Theory of Arrhenius. E. Fouard. (Journ. de Physique, 8. Ser. 5. pp. 629-641, Aug., 1918.)—The author has already found that when his own method of measuring osmotic pressures is used, potassium chloride gives a normal value instead of the double value of the theory of electrolytic dissociation and, for instance, of Griffith's measurements of freezing-points. He now shows that the lowering of the vapour pressure is substantially the same for normal solutions of potassium chloride and of cane-sugar, the i -factor being 1.67 for the former and 1.66 for the latter, and the "degree of dissociation" α being calculated as 67 % for KCl and 68 % for sugar. The origin of the anomaly is discussed, but without coming to any precise conclusion.

T. M. L.

577. Solubility of Radium Emanation and Other Gases in Liquids. S. Meyer (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1281-1294, July, 1918.)—The author shows that the solubility of RaEm and a series of other gases (H_2 , N_2 , CO , NO , O_2 , Ar) in water can be expressed by the formula $\alpha = A + B e^{-\theta/\nu}$, where A is the amount dissolved at the boiling-point, $A + B$ the amount dissolved at the melting-point, and ν is a constant which characterises the liberation of gas with rising temperature. The same formula also holds for other liquids if θ be expressed in terms of the difference between the melting- and boiling-points. It is found that the constant ν is practically independent of the particular gas or solvent. E. M.

578. Attempts to Separate Radium D from Lead. F. Paneth and G. v. Hevesy. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 998-1000, May, 1918.)—According to recent speculations on the chemical nature of the radio-elements [see Soddy, Abstract No. 170 (1914)] it is to be expected that RaD and lead should be chemically non-separable. In the present experiments exhaustive attempts were made to effect a separation, but with no success. In addition to numerous chemical precipitations, electrolysis of the solution and the fused salt was tried, also diffusion, dialysis, and distillation at $1000^\circ C$. E. M.

579. Radio-elements as Indicators in Analytical Chemistry. F. Paneth and G. v. Hevesy. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1001-1007, May, 1918.)—Since most of the radio-elements can be detected when present in extremely small amounts, the authors suggest their use as indicators in various operations. For instance, in investigating the solubility of lead chromate in water or of lead sulphide in saturated H_2S solution advantage can be taken of the fact that when RaD is once mixed with the salt, its concentration cannot be altered [see preceding Abstract]. Consequently, by determining the relative activities of the dissolved and undissolved lead salt, the solubility can be determined. The experiments give 1.2×10^{-4} gm. per litre at $25^\circ C$. for lead chromate in water, and 1.5×10^{-4} gm. per litre at $25^\circ C$. for lead sulphide in water saturated with H_2S . E. M.

580. Colloidal Solutions of Radio-elements. F. Paneth. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1079-1084, June, 1918.)—In continuation of the experiments described in Abstract No. 1748 (1918), the author finds that the nitrates of those radio-elements which dissociate hydrolytically, easily split up forming colloidal solutions of hydroxides. E. M.

581. Extraction of Polonium. F. Paneth and G. v. Hevesy. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1049-1052, June, 1918.)—The paper deals mainly with the separation of polonium from the radio-lead residues of pitchblende. By electrolysis of the solution, using a p.d. of only 0.08 volt the Po is concentrated on the kathode. However, the only method of completely separating Po once it has been deposited on Pt, is by distillation at $1000^\circ C$., preferably in a quartz tube with a feeble stream of CO , or H . When the Po is condensing it has different affinities for different surfaces. Thus if similar cold sheets of Pt and Au are exposed, nearly 40 times as much is deposited on the Pt as on the Au. Pd is still better than Pt. The authors consider, however, that the best method of obtaining Po from solution is by rotating a sheet of copper in it, 80 % of the Po being deposited. Another method of separation is by dialysis [see Abstract 1748 (1918)]. E. M.

582. *Electro-chemical Interchangeability of the Radio-active Elements.* F. Paneth and G. v. Hevesy. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1087-1047, June, 1918.)—Experiments are described showing that the disintegration points of ThC, and RaE are the same as that of Bi, those of RaD and ThB the same as that of Pb, that of RaA about that of Po. The separation of ThB is checked by the presence of Pb, and that of ThC or RaE by the presence of Bi. It is pointed out that this fact affords a means of considerably increasing the purity of radio-active elements separated by electrochemical means. The anodal separation of Po and other radio-active elements is satisfactorily explained on the view that the potential, and not the current, is the important factor that comes into play. The separation of ThB at extraordinarily high potentials is accounted for by the formation of ThB-superoxide which has the same disintegration point as PbO₂.
E. A. O.

583. *Effect of Light on Decomposition Voltage.* A. Leighton. (Journ. Phys. Chem. 17. pp. 695-702, Nov. 1918.)—A mercury lamp was immersed midway between the electrodes in an electrolysis cell containing copper sulphate solution. By means of a rubber cloth it was possible to shield either electrode from the light or both electrodes if necessary, and the decomposition voltage could thus be read under varying conditions of illumination of the electrodes, which were either of graphite or platinum. It was found that the decomposition voltage between Pt electrodes is not affected appreciably when the anode alone is illuminated, but is decreased when the kathode is illuminated. It is possible to regulate the voltage so as to make copper deposit on the shaded portion of a Pt kathode and not on the illuminated portion. Graphite adsorbs a cuprous salt from a solution of copper sulphate, which acts as an anodic depolariser and can be removed by electrolytic oxidation; the reaction is accelerated by light. Owing to this adsorption the decomposition voltage for a copper sulphate solution with a graphite anode and a Pt kathode can be brought down temporarily to about 0.4 volt.
T. S. P.

584. *Electrolytic Reduction of Iron for Analysis.* J. C. Hostetter. (Washington Acad. Sci., Journ. 8. No. 16, 1918. Chem. News, 108. pp. 289-240, Nov. 14, 1918.)—The author describes an electrolytic method for the reduction of ferric to ferrous salts in sulphuric acid solution, preliminary to the estimation of the iron by titration with permanganate. A gold dish kathode is used and a Pt anode, the latter being surrounded by a small porous pot. 0.5 gm. of iron in the ferric state is reduced in 60-120 mins., using 4.8 to 10 amps. at 4.5 to 10 volts.
T. S. P.

585. *Rapid Refining of Copper with a Rotating Kathode.* C. W. Bennett and C. O. Brown. (Journ. Phys. Chem. 17. pp. 685-694, Nov., 1918.)—An apparatus is described by which the electrolytic refining of copper can be demonstrated to students. Currents as high as 65 amps. per dm.² at the kathode can be used, and 100 gm. of copper deposited in an hour. Experiments are described in which the usual impurities of copper are separated from artificially prepared anodes. Working scale drawings are given of the apparatus. The kathode makes about 5000 revs. per min. [See Abstracts Nos. 1294 (1913) and 1878 (1918).]
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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1914.

GENERAL PHYSICS.

586. *Instrument for Solving Spherical Triangles.* (Eng. News, 71. pp. 180-181, Jan. 22, 1914.)—Describes, with photographs, an instrument called the "mechanical navigator," which solves mechanically, by the setting-off of angles on rotating arcs, all the problems in spherical trigonometry which arise in navigation. By manipulating the instrument a navigator may find in one operation a ship's place at sea from two sights, making allowance for the ship's run. This is equivalent to solving three spherical triangles simultaneously, thus avoiding the use of the method of the Sumner lines, or their treatment by the method of Saint-Hilaire. The result thus found mechanically is claimed to be within 2' of arc, or less than the theoretical errors of the above methods. A detailed description is given of the method of use in certain cases. A. W.

587. *Micro-balance for Determining Densities of Small Quantities of Gases.* F. W. Aston. (Roy. Soc., Proc. Ser. A. 89. pp. 489-446, Jan. 1, 1914.)—A simple form of micro-balance is described, by which the densities of gases may be determined relative to some standard gas, using a null method. The apparatus is similar in principle to the quartz micro-balance of Steele and Grant [Abstract No. 1988 (1909)], subsequently used by Gray and Ramsay [Abstract No. 1768 (1910)] in determining the density of RaEm. This instrument was made with a small quartz bulb fixed to one end of the beam, the weighings being done by altering the pressure of the air in the balance case. By knowing the buoyancy of the bulb and observing the pressure necessary to bring the beam to zero, the weight at the other end of the beam could be calculated. If, however, the bulb is balanced by a fixed counterpoise, the pressure necessary to bring the beam to zero will be a measure of the density of the gas in the balance case. The moving part of the balance is made of fused quartz; it turns upon a simple knife-edge cut on a piece of quartz rod about 0.5 mm. thick. To this rod, a few mm. above the knife-edge, are fused two others of about the same thickness, forming the arms of a beam. To the end of one arm is fused a quartz bulb (volume about 0.8 c.cm.) and to

the other a counterpoise made from a piece of rod about 2 mm. thick. The total length is about 5 cm. and the weight of the whole is under 0.2 gm. The balance is designed to be operated at pressures of about 100 mm. of mercury, and by special construction the volume of the balance case was reduced so that only about 0.5 c.cm. of gas is required. The determination of the density can be performed in a few minutes, with an accuracy of 0.1 %. Possibilities of the use of the balance in other fields of research than that for which the apparatus was designed (comparing the densities of specimens of neon) are indicated.

A. W.

588. *Gardner's Gyroscope*. (Engineering, 97. p. 229, Feb. 18, 1914.)—Describes the specially free-running gyroscope for use in steering a torpedo. It may be spun by a jet of compressed air directed on to buckets in its periphery. With an initial speed of 4000 revs. per min. the total run may last about 85 mins., the diam. being 8 in. and the mass 2 lbs.

E. H. B.

589. *Determination of Level with Mercury Bath*. A. Broca and C. Florian. (Comptes Rendus, 157. pp. 1044–1047, Dec. 1, 1918.)—In order to avoid the difficulties introduced by the temperature effect on air-bubble levels, a method has been developed of utilising a mercury surface treated to subdue the small oscillations due to vibration. Various viscous liquids were tried, but the best combination for bearing transport from place to place was found to be glycerine over the mercury surface, enclosed in an exhausted box. For work at low temperatures it is recommended to add a little absolute alcohol to the glycerine. The top of the box is made of plane-parallel glass, the under surface being in contact with the glycerine. To the upper surface of this plate is cemented an objective furnished with an auto-collimating eyepiece. The deviations observed in the focal plane are then multiplied by the index of refraction of the glycerine.

C. P. B.

590. *Density of Some Metals in the Liquid State*. P. Pascal and A. Jouniaux. (Comptes Rendus, 158. pp. 414–416, Feb. 9, 1914.)—The authors have applied the use of a quartz float to the determination of the density of fluid metals up to 1800°C. At the fusion points of the respective metals the following values were obtained :—

Tin.....	6.96 (282°C.)	Antimony.....	6.55 (681°C.)
Lead	10.875 (827°C.)	Aluminium	2.41 (658°C.)
Zinc	6.92 (418°C.)	Copper	8.40 (1088°C.)

For these metals equations have been worked out showing the relationship between specific volumes and temperatures. The specific volume curve for tin shows a marked inflection at 620°C., showing a rapid increase in dilatation at high temperatures. This appears to be a case of dynamic allotropy, similar to that observed in a number of other substances, notably sulphur, at low temperatures. There is a certain analogy between the shapes of the dilatation curves before and after fusion.

F. C. A. H. L.

591. *Acoustical Estimation of Density of Gas or Liquid*. A. Kalähne. (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 81–92, Jan. 80, 1914.)—This method depends upon the fact that a solid moving in a fluid is loaded by a portion of that fluid. Hence, if the solid is in vibration, its period is slightly increased by this loading. An aluminium tube is set in lateral vibration of the fundamental mode having two nodes at which it is held by screw points. Then,

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using the apparatus with air and other gases in turn, and noting the changes in frequency (say, by beats with a like apparatus in the standard state), the dependence of frequency on the density of the gas is found. Hence the density may be inferred in any like case.

E. H. B.

592. Designation of Units for which Equations Hold. F. F. Martens. (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 97-99, Jan. 30, 1914.)—Recommends that in an equation which holds between the numerical values of quantities, the units for each factor should be shown as subscripts. Thus $f_m = l_m b_m$ for the area f in square metres of a rectangle of length and breadth l and b metres. Or, again, Young's modulus in special units may be shown by—

$$E_{\text{kg.wt./mm.}^2} = \frac{l_{\text{cm.}}}{\lambda_{\text{cm.}}} \frac{\text{Pkg.wt./mm.}^2}{q_{\text{mm.}^2}}$$

E. H. B.

593. Relativity Theory. S. Mohorovičić. (Phys. Zeitschr. 14. pp. 988-989, Oct. 15, 1918.)—Illustrates the conclusion "that the sum of two velocities approaching the velocity of light never exceeds the velocity of light" by means of Lobatchevski's non-Euclidian geometry of hyperbolic planes.

E. E. F.

594. Deviation of Falling Weights. G. Gianfranceschi. (Accad. Lincei, Atti, 22. pp. 561-568, Dec. 7, 1918.)—Allows a weight to fall 82 m. in an arrangement resembling Atwood's machine. The weight has a steel point which pricks a cardboard target. The mean easterly deviation due to the earth's rotation is 1.866 mm. There is also a small northerly deviation amounting to 0.088 mm. By Gauss's theory the former should be 2.081 mm., and the latter should be zero. In spite of these discrepancies Gauss's theory corresponds better with observed values than the theories of Woodward or Hagen.

E. E. F.

595. Canonical Relations in General Dynamics. A. Gray. (Phil. Mag. 27. pp. 22-48, Jan., 1914.)—An analytical treatment of the subject in terms of generalised co-ordinates. For details the original should be consulted as its nature renders its unsuitable for abstraction.

E. H. B.

596. Experimental Determinations of the Viscosity and Density of Molten Metals and Alloys. R. Arpi. (Int. Zeitschr. Metallg. 5. pp. 142-168, Jan., 1914.)—Determinations of the viscosities of fused metals, which had previously been carried out only with mercury, have been made on cadmium, tin, lead, and bismuth, and on Pb-Sn and Pb-Bi alloys at temperatures ranging from the melting-points to 550°. Poiseuille's method was followed, and the viscosity vessel, which was of quartz, was calibrated by means of mercury; hydrogen containing methyl alcohol was found to give a suitable reducing atmosphere. The viscosities of the metals investigated are of the same order of magnitude, and are in the same order as the melting-points. With Cd, Hg, Sn, and Pb the fall in the viscosity with rise of temperature increases in greater proportion than the value of η , but in the case of Bi the fall is relatively less. The viscosities of the fused Pb-Sn alloys are somewhat smaller than would be the case if the law of mixtures held rigorously, and the same holds with the lead-Bi alloys, for which the discrepancy is more marked at low temperatures. The temperature-coefficient of the viscosity is extremely small for the Pb-Bi alloys, and with the higher concentrations of Bi appears to be even lower than that of pure Bi. The

specific gravities of the above metals were also investigated at different temperatures; the values found for the alloys are smaller, although scarcely appreciably so, than those calculated from the law of mixtures. T. H. P.

597. Edge-angle and Spreading of Liquids on Solids. A. Pockels. (Phys. Zeitschr. 15. pp. 89-46, Jan. 1, 1914.)—In measuring the edge-angle of a liquid on a solid, the utmost importance attaches to the cleanliness of the solid surface, and instructions are given for attaining this. In order to test if the surface is clean or contaminated by fatty or resinous substances, it is dipped into a freshly formed water surface previously dusted over with lycopodium, charcoal, or talc; the floating particles will be repelled and a dust-free zone formed round the surface, if the latter is in the slightest degree dirty. The edge-angle formed by a liquid spreading out on a solid plate and that formed when it is spread out by means of a wire and then allowed to draw together are virtually identical with certain liquids, e.g. benzene; the drop then slides on the solid in the same way as does mercury on glass. But with other liquids, such as water and glycerine, a marked difference is observed in the behaviour on spreading and on drawing together; these liquids adhere or cleave to the solid surface. Some of the results of the numerous measurements made with both clean and dirty surfaces are as follows. With water on glass, the edge-angle on contraction of the drop is zero, so that clean glass is wetted by water; the same is the case with water on Pt, and with glycerol on glass or Pt. Alcohol, oil of turpentine, and petroleum spread out on glass or Pt to an unlimited extent to form coloured films. With benzene, ether, or carbon disulphide, the edge-angle very quickly assumes its definite value, which is approximately the same when produced in either way; the drops slide on the surfaces without wetting them. In the case of various oils and oleic acid the cleanliness of the surface is of little moment; but the removal of fatty acids from oil renders the latter more mobile, so that the drop may be slid slowly over the surface, whereas unpurified oil adheres tightly. With surfaces which have not been cleaned by heating, edge-angles are exhibited by many liquids not showing them on clean surfaces. It may be assumed that, besides the liquids examined by the author, many other liquids, especially organic substances, form edge-angles, and these should be taken account of in measuring surface tensions by means of capillary rise. Experiments were made also with strips of copper and zinc, which cannot be cleaned by heating, and were consequently filed with a file frequently used beforehand on the same metal; the results are rendered slightly indefinite by the file-marks, any polishing being inadmissible. Freshly-filed zinc and copper are wetted by water, and the same happens after some hours, while, as with heated Pt, the edge-angle formed on spreading increases rapidly with the time. Smooth fractures of different coals were also examined.

The results obtained are tabulated, and various theoretical consequences considered. T. H. P.

598. Spontaneous Alteration of Liquid Surfaces. C. Cloarec. (Comptes Rendus, 158. pp. 482-484, Feb. 16, 1914.)—By the method of Duclaux the variations of the surface tension of a liquid can be followed by counting the number, N , of drops furnished by a volume V of that liquid. Suitably modified, this method can be employed for studying the properties of the superficial layers of liquids. By this means the following results have been obtained. When water is left in an uncovered vessel the number N remains constant for the first 8 hours, then it decreases gradually, until at the end of about 50

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hours a value is reached which no longer varies with the time. This is explained by the fact that the effect of contact with air is to cover the surface of the water with a kind of membrane the thickness of which increases with the time. When the thickness of this membrane is sufficient to mask completely the action of the subadjacent water, the corresponding value of N is a characteristic of the new superficial layer and is no longer modified by an increase in the thickness of this membrane. With a salt solution N varies from one experiment to the next, indicating a rapid spontaneous alteration of the surface layer. The principal cause of this appears to be of internal origin. If increasing quantities of some oil, such as olive oil, be placed on the surface of water, and the variations of N with the thickness of the layer of oil be represented graphically, a curve is obtained similar to that obtained with the salt solution. The spontaneous alteration of liquid surfaces is also found to be so much the greater and more rapid the smaller the surface. A. E. G.

599. *Phenomena of Fluid Motion.* W. S. Franklin. (Frank. Inst., Journ. 177. pp. 28–38, Jan., 1914.)—Discusses the apparent attraction of a pair of balls, hanging side by side, when a jet of air is blown between them; the explanation being that the air-pressure is less where the speed is greater, on Bernoulli's principle. On the same principle a ball or a file handle may be supported by an air-jet. The swerving flight of a ball which spins as it passes through the air is also discussed, the swerve being towards the side to which the leading part of the ball is turning. This again follows from the same principle, as is easily seen if the ball be imagined still and the air blowing past it. Then the air speed is *less* where it meets the *advancing* side of the spinning ball. Accordingly the pressure is greater, and the ball swerves as stated.

E. H. B.

600. *Efflux from a Vessel Perforated in the Base.* U. Cisotti. (Accad. Lincei, Atti, 22. pp. 478–478, Nov. 28, 1918.)—The author considers a rectangular vertical vessel of width Ω , with a very small orifice in the centre of the base, a constant efflux, q , of liquid occurring. It is shown analytically that the surface of the liquid falls horizontally with constant velocity, q/Ω , until its distance from the base of the vessel is sensibly equal to Ω . Near the orifice the lines of flow are virtually tangent curves, while in the particular case where the vessel is infinitely wide they take the form of rays converging to the orifice.

T. H. P.

601. *Motion of Long Air-bubbles in a Vertical Tube.* A. H. Gibson. (Phil. Mag. 26. pp. 952–955, Dec., 1918.)—The motion of an air-bubble rising, under gravity, through the liquid in a vertical tube depends largely on its dimensions, both absolute and relative to those of the tube. With a very small bubble the form is approximately spherical and the motion steady, but as the size is increased the shape changes, becoming more and more contracted in a vertical direction, while the curvature of the lower surface becomes much less than that of the upper. Tubes of moderate dimensions accentuate these changes, and when the bubble diam. is between $\frac{1}{2}$ and $\frac{3}{4}$ that of the tube very irregular motion ensues, for not only does the bubble zigzag across the tube from side to side, but violent oscillations take place about a horizontal axis, showing the periodic variation of the magnitude and distribution of the pressure on its lower face, due to eddy formations in its rear. With further increase in size, the irregularities diminish until, when the diam. is about 0.75 times that of the tube, the bubble begins to adopt a more or less cylindrical

form with an ogival head and flat stern, and the motion becomes steady. Any further increase in volume is mainly effective in increasing the length of the cylindrical portion of the body, the form of the head remaining sensibly unchanged, and the mean diam., although increasing with length, not altering greatly. The bubble body is not actually of the same diam. throughout, but gradually increases to a maximum at its lower extremity. If the tube bore exceeds about 1 cm., such a bubble shows a beautiful series of well-defined waves or ripples around the lower portion of its barrel. These are stationary relative to the surface of the bubble, and when the length of the latter does not exceed the bore of the tube, are of comparatively large amplitude and length and extend over the whole length of the bubble. As the length increases the wave-length and amplitude and the extent of surface covered by the ripples diminish rapidly, while with a given length of bubble the wave-length diminishes with an increase in the bore of the tube. If the bore is less than about 1 cm. the ripple formation is somewhat peculiar. Immediately ahead of the stern of the bubble a ripple consisting of a single depression of comparatively large amplitude and length is formed, and for lengths greater than about two diameters even this is not fully developed. Where the bubble passes any slight roughness in the interior surface of the tube, however, a series of true ripples of very much smaller pitch make their appearance. The author examined these phenomena for the case of air-bubbles moving through water, using a series of glass tubes of diams. ranging from 0.42 cm. to 7.78 cm. Each tube was mounted vertically, an air-bubble being introduced by means of a rubber bulb at its lower end, and, when the motion had become steady, the time taken to traverse a known distance was measured by chronograph. Instantaneous photographs having an exposure $1/1000$ second was taken of bubbles of various lengths up to 8 cm., and specimens of these are given in the paper. In the case of long bubbles, the unexpected result was found that if the bubble is so long as to adopt a cylindrical form, i.e. for lengths greater than the bore of the tube, the mean velocity is sensibly independent of the length within the limits of length investigated. Tables of results are given.

Ripple-formation on the surface of a bubble is then experimentally and mathematically investigated. The system of ripples on the surface of a long bubble appears to be analogous to that found at the up-stream side of an obstacle piercing the surface of a running stream, the disturbance produced by the sudden change of section and of velocity in the rear of the bubble being analogous to that due to the presence of the obstacle in the latter case. A series of experiments was carried out to investigate the effect of viscosity and of the solid boundaries. In these a steady stream of water from a vertical nozzle was allowed to impinge on the centre of a circular horizontal glass plate 20 cm. in diam., flow taking place radially outwards in all directions. The discharge was caught and weighed, the depth of the sheet of water being measured at a series of radii by means of a spherometer with a needle-point which was gradually lowered to make contact with the fluid surface. Ripples were then formed at these same radii by means of a needle-point, and their length measured by microscope. The limiting length for stability of flow past the bubbles is finally dealt with, and the result obtained that in very long bubbles stream-line motion breaks down, as indicated by the observed frosted appearance of the film at some distance from the head of the bubble. From data obtained it appears that the larger the tube the thicker the film between bubble and tube for bubbles having similar ratios of length to diam., so that the tendency to instability must be greater in a large than in a small tube.

H. H. Ho.

602. *The Surface Tension, Platinum-Water.* K. Tangl. (Ann. d. Physik, 42. 6. pp. 1221-1240, Dec. 28, 1918.)—Using the method described previously [Abstract No. 584 (1911)] the author has determined the surface tension, referred to dry and moist air, between caoutchouc-water, collodion-water, shellac-water, and Pt-water. In order to measure the deformations, according to the author's method, a caoutchouc tube was coated with either shellac or collodion, and, for the measurements with Pt, afterwards coated with Pt by cathodic disintegration. The surface tension referred to dry air varies considerably for the different substances, but is approximately the same when referred to moist air, probably because of an adsorbed layer of moisture. The surface tension Pt-water is constant when the thickness of the Pt layer is greater than $52\ \mu\mu$. T. S. P.

603. *The Energy Systems accompanying the Motion of Bodies through Air and Water.* J. B. Henderson. (Inst. of Naval Architects, Trans. 55, Part I, pp. 88-98, 1918. Engineering, 95. pp. 549-550, April 18, 1918.)

604. *Methods of Physical Science and their Range of Applicability.* A. G. Webster. (Science, 89. pp. 42-51, Jan. 9, 1914.)—A semi-popular survey of the methods, progress, and range of physical science. E. H. B.

605. *Correlations of Pressure and Temperature in the Northern Hemisphere in Winter.* F. M. Exner. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1165-1240, June, 1918.)—This is an account of a systematic investigation by the method of correlation coefficients into the inter-relations of deviations from normal of monthly means of temperature and pressure in the winter months over the Northern Hemisphere. Forty-nine stations distributed as evenly as possible are selected, and the means of pressure and temperature for the months Dec., Jan., and Feb., for each of the 20 years 1887 to 1906, are extracted. A correlation coefficient of -0.57 is found between the mean of the pressures at the polar stations Markowo and Gjesvaer and the west component of wind velocity at Potsdam Observatory, and upon the basis of this result the "polar pressure" is taken to be a measure of the intensity of the general atmospheric circulation, a high polar pressure corresponding with a weak circulation, and *vice versa*. Correlation coefficients are therefore found between polar pressure and simultaneous pressures for all the other stations, and lines of iso-correlation are drawn upon a map of the Northern Hemisphere to show the results. Naturally they indicate a closed area of high positive correlation around the pole ($> +0.8$), and the lines for 0.6 , 0.4 , 0.2 and 0.0 are closed curves running roughly east and west, situated at increasing distances from the pole. The line of zero correlation lies on the average at about 50°N ., and passes through the middle of the British Isles. South of this line as far as the equator the correlation coefficients are everywhere negative, and over the Mediterranean they attain the large value of -0.6 (-0.70 at Algiers) where there is a closed curve of that value. Over the West Indies the values are also numerically high (Port au Prince -0.46). The "see-saw" variations of pressure between polar regions and the lower part of the North Atlantic, which have often been pointed out, are thus strikingly shown, while the method of indicating the iso-correlation lines reveals the markedly zonal distribution of the coefficients in the Northern Hemisphere during the winter months, and proves that an increase of pressure at the pole is compensated by a decrease in low latitudes, and conversely.

Correlation coefficients are similarly obtained between polar pressure and simultaneous monthly means of temperature at all the stations, and lines

of iso-correlation for these are also shown on a map. The main features of this map are (1) high negative values over Northern Europe and Asia, with minimum (< -0.6) over the British Isles; (2) positive correlation ($> +0.4$) over the South-Eastern Mediterranean; (3) positive values ($> +0.4$) over Davis Strait, and (4) negative values (< -0.2) over the West Indies. The lines of zero correlation run (a) north and south up the middle of the Atlantic, over the pole and out over the Pacific; (b) east and west across the United States; (c) east and west along the north shore of the Mediterranean and out on the Pacific across China. The author shows how this distribution might be predicted in outline from the corresponding map of pressure correlations. To illustrate the meaning of the map it may be stated that high pressure in polar regions in winter is shown to be connected with low temperature over the British Isles (see (1) above) in winter. Correlations of pressure between pairs of stations are worked out, and the results plotted on a diagram in which the difference in longitude between the stations is taken as abscissa. The partial correlations of the same pairs of stations are also given, assuming polar pressure to be constant, *i.e.* eliminating the effect of variations in the intensity of the general circulation. In the former case the curve obtained shows large sinuosities, in the latter it is much more regular. The general result from both diagrams is that the algebraic value of the correlation coefficient gradually decreases from $+1.0$ at 0° difference of longitude to -0.4 at 180° difference.

In the second part of the paper an examination by means of the methods of partial correlation is made into the connection between conditions at one station in one month and the ascertained conditions at other stations in the preceding month, and equations are obtained which might form the basis of a forecast of weather for a month in advance. Thus an equation is derived connecting pressure at Stykkisholm (Iceland) with the preceding month's pressures at Lemberg, Ivigtut and Jakutsk, while a second equation gives a value for pressure at Ponta Delgada (Azores) in terms of the preceding month's temperatures at Novorossisk, Gjesvaer and Jakutsk.

R. C.

606. *Studies of the Nocturnal Radiation to Space.* A. Ångström. (Astrophys. Journ. 89. pp. 95-104, Jan., 1914.)—The paper describes some experiments made to determine the amount of the nocturnal radiation from the surface of the earth to different parts of the sky. The apparatus used consisted of an Ångström nocturnal compensation instrument shielded behind a hemispherical screen with a small circular opening in the line perpendicular to the radiating strips. The whole apparatus could be turned about so that the opening faced different parts of the sky and thus measurements were made of the "effective radiation"—that is, the difference between the outgoing and the incoming radiation—from a surface lying perpendicular to the radiated beam. From this the radiation from a horizontal surface like that of the earth to different zones of the sky can be computed. Observations were made at Bassour, Algeria, and curves are given in the paper for three occasions of different surface humidity. Measurements in the daytime have to take account also of the diffuse radiation from the sky of short wave-length which comes in addition to the pure temperature radiation. From such measurements the author concludes that this diffuse sky radiation overpowers the "effective temperature radiation to the sky" or resultant night radiation, to a slight degree. The result differs from that of Homén who concluded that there was an effective radiation from the earth to the sky even in the daytime.

J. S. DI.

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607. *Air-waves in Valleys according to Records from Variographs in Innsbruck.* W. Schmidt. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 885-911, May, 1918.)—Two "variographs," or instruments which record the rate of change of atmospheric pressure [see Abstract No. 569 (1918)], were set up in Innsbruck for these experiments. Many hours before the beginning of föhn the instruments exhibit extremely regular waves with periods varying between 5 and 12 mins. The amplitudes of the waves increase continuously as the warm föhn current aloft sinks to the surface until they suddenly end when the föhn breaks through. The phenomena are explained as air-waves formed in the atmosphere at the upper surface of the cold valley wind over which blows the warm current of the föhn. The variations in pressure immediately below the interface between the two air-currents, occasioned by the troughs and depressions of the waves, are transmitted without change to the surface where they are recorded on the variographs. The observed results agree well with those obtained by the theory of waves formed at the interface between two fluids moving with different velocities. The max. height of the air-waves, from crest to trough, is shown by the application of the theory to be of the order of 100 to 150 metres, corresponding with a pressure-variation of at least 4 mm. of mercury. The length of the waves is of the order of kilometres and their velocity is about half that of the föhn. The presence of air-waves as indicated by the variograph is regarded as evidence of rapid variations in the density and velocity of the air-layers aloft, while absence of air-waves shows that the atmosphere aloft exhibits regular and normal changes in these quantities. The appearance of air-waves is frequently associated with an advancing depression, and may thus be regarded as a weather prognostic. It is considered that seiches in lakes and föhn-sickness may be connected with air-waves, and it is pointed out that although such waves are shown in a well-developed state in the Alpine valleys, yet they may be produced in any other locality where the required condition of two currents of unequal density, the one flowing over the other, is satisfied. R. C.

608. *Virtual Temperature of the Sky.* A. Lo Surdo. (N. Cimento, 5. Ser. 6. pp. 487-451, June, 1918.)—Assumes the visible sky to radiate heat as a black body, and, by noting the temperature of an Ångström radiator, determines the exchange of heat between the two bodies and thus the "virtual temperature" of the sky by Stefan's law. This is done for a station in Naples and another at the observatory on Monte Cimone at an altitude of 2170 m. Measurements taken in August show a rapid fall at Naples at sunset down to about $-70^{\circ}\text{C}.$, and on Monte Cimone down to -28° , setting in rather late and recovering more rapidly at sunrise. E. E. F.

609. *Sunshine Record at Spitzbergen.* M. Robitzsch. (Meteorolog. Zeitschr. 80. pp. 594-599, Dec., 1918.)—A description is given of the type of instrument to be used in recording sunshine duration and intensity, comprising a photographic paper cylinder machine, and the method of determining the form of the curves traced by the sun at different altitudes. C. P. B.

610. *Energy Spectrum of the Sun.* A. Defant. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1185-1168, June, 1918.)—A series of comparisons are made of the transmission coefficients by Vogel and Scheiner, and Abbot, and the theoretical values calculated from terrestrial experiments on bodies at high temperatures. C. P. B.

611. *The Hintereis Glacier.* R. M. Deeley and P. H. Parr. (Phil. Mag. 27. pp. 158-176, Jan., 1914.)—The authors have shown in a previous communication that the ellipse is a very unsuitable form of curve to use for studying the flow of such a glacier as the Hintereis, since it makes the edges of the ice-stream vertical instead of inclined [see Abstract No. 1590 (1918)]. The present paper is a further consideration of this question, especially as regards the curve of glacier slip and its probable amount; the conditions of shear stress and temperature within the glacier; crevassing and viscosity. The surface motion has been found to be the sum of two movements, one a bodily slip of the whole mass on its bed, and the other a result of the differential motion of the ice of the glacier. These movements have received detailed experimental study, the different apparatus used being fully described, and grounds are given for holding that the motion or slip of clean ice upon a hard but slightly rough surface may take place without abrasion of either the rock or ice. The conditions of flow of the Hintereis Glacier itself are then exhaustively considered, curves, diagrams and tables being given, while the paper finally contains a short mathematical discussion of the distribution of shear force in a viscous fluid flowing along Parr's channel. H. H. Ho.

612. *On the General Distribution of Seismic Movements.* de M. de Ballore. (Comptes Rendus, 158. pp. 440-441, Feb. 9, 1914.)—The paper is a summary of the principal deductions to be made from Milne's British Association Reports (1899 to 1909), which contains data recorded by 59 observatories. Since hardly a fifth of the earth's surface is accessible to direct observation, Milne's indirect method of attacking the seismological problem has to be adopted. The observational period of eleven years has provided 881 epicentres, and the author draws many interesting conclusions from their distribution. Among others he points out that the ratio of the number of submarine to terrestrial epicentres is 8 to 1, *i.e.* the same as the immersed to the emerged surface, so that there is uniformity in distribution between subterranean and terrestrial movements. In general the degree of seismicity is reflected in the geological vicissitudes of the area, so that a new mode of investigating oceanic geology is opened out. A number of interesting applications of the latter conclude the paper. H. H. Ho.

613. *Impersonal Coincidence Micrometer.* A. Verschaffel. (Comptes Rendus, 157. pp. 975-977, Nov. 24, 1913.)—The author criticises the claims of Claude and Driencourt with respect to their new impersonal coincidence micrometer [Abstract No. 177 (1914)], pointing out that it by no means eliminates personal equation; for although several of the usual effects of personal equation may be allowed for, others will be introduced. It is also considered that the instrument will be difficult to construct and laborious to use. C. P. B.

614. *Absence of Refraction in Solar Atmosphere.* G. Gouy. (Comptes Rendus, 157. pp. 1111-1114, Dec. 8, 1913.)—In a former note [Abstract No. 1797 (1913)] it was suggested that it was unnecessary to consider the effect of refraction in the solar atmosphere on account of the extreme tenuity of the constituent gases. A few theoretical points are now considered in the application of the results of laboratory experiments to the interpretation of solar phenomena. With respect to the suggested action of anomalous dispersion, it is pointed out that such phenomena generally require the presence of relatively great density gradients, while the evidence available points to the solar atmospheric gases being extremely rare.

615. Notes upon Hale's Investigations for Determining the Sun's Magnetism. K. Birkeland. (*Comptes Rendus*, 157. pp. 894-896, Aug. 25, 1918.)—Hale has recently stated [Abstract No. 84 (1914)] that the sun is magnetic with polarity analogous to that of the earth, and having a vertical intensity at the poles of about 50 gauss. To the present author these results seem to contradict those of other researches when the general magnetism of the sun is assumed to conform to that of the earth, since the helio-kathodic rays which produce the terrestrial magnetic perturbations and aurora would never reach the earth if the sun were magnetised similar to the earth but with an intensity 70 times as great [see Abstract No. 781 (1918)]. Hale, however, is of the opinion that solar magnetism differs radically from that of the earth, since it is probable that the field intensity decreases rapidly after traversing the reversing belt. This presents an interesting resemblance to the field produced by sun-spots. To the author it appears that the effects produced may be explained as due to invisible spots or to electric whirls, in spite of all the reasons urged by Hale against such a supposition. The author gives a reasoned argument in the paper in favour of his standpoint and against that taken up by Hale. According to the author's researches the magnetic moment of the sun is of the order 10^{26} c.g.s. and the magnetisation is directed in a contrary sense to that of the earth. H. H. Ho.

616. Eclipse Spectrum of Chromosphere. S. A. Mitchell. (*Astrophys. Journ.* 88. pp. 407-495, Dec., 1918.)—The paper gives the detailed results of the measurement of the spectra obtained at Daroca, Spain, during the total solar eclipse of Aug. 30, 1905, a preliminary account of which has already been published [Abstract No. 853 (1906)]. The spectrographic equipment consisted of five instruments, three of small and two of large dispersion. The present paper deals chiefly with the results given by the large instruments: (1) a parabolic grating 4 in. diam. and 5 ft. (150 cm.) focal length, with 14,438 lines to the inch; (2) a plane grating, with 15,000 lines to the inch, used in conjunction with a 5-in. visual lens of 72 in. (184 cm. focus). The spectra obtained at third contact, the end of totality, were selected for measurement, and tables of 2841 lines are given, extending from $\lambda 8818.16$ to $\lambda 6191.6$, with the probable origin, relative intensities of the lines in Fraunhoferic, chromospheric, arc and spark spectra, and the estimated height of the layer giving each line, determined from the length of the bright arc left uncovered by the eclipsing moon. Out of the whole 2841 lines only 126 are unidentified as regards the elements producing them. The general list of elements present is practically identical with that giving the substances represented in the solar spectrum, but the distribution of the relative intensities of the lines is widely different. This is summarised by dividing the elements present into three groups: (1) elements whose lines are strong in both the Fraunhoferic chromospheric spectrum, Ca, Mg, Al; (2) elements whose lines are relatively stronger in the chromospheric than in the solar spectrum, H, He, Ti, Cr, C, V, Zr, Se, La, Y, Sr, Ba, Nd; (3) elements whose lines are relatively weaker in the chromospheric than in the solar spectrum, Fe, Ni, Co, Mn, Na, Nb, Mo, Pd. No conclusive evidence was obtained of the presence of radium or the other radio-active elements. C. P. B.

617. Change in Lunar Crater Eimmart. W. H. Pickering. (*Astronom. Nachr.* No. 4704. *Nature*, 92. p. 594, Jan. 22, 1914. Abstract.)—Observations at the Harvard Station at Mandeville, in Jamaica, indicate that some change has recently taken place in the lunar crater Eimmart. The crater lies on

the N.W. border of the Mare Crisium, and is about 25 miles in diam. Formerly this crater appeared at each lunation much brighter than any similar area between it and the limb, as if it were filled with white material, the source of which appeared to be at the foot of the northern interior slope. During the last year the whiteness appears to have decreased, and recently the phenomenon has not been visible. C. P. B.

618. *Ultra-violet Solar Spectrum at High Altitude.* A. Wigand. (Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1090-1099, Nov. 15, 1918. Phys. Zeitschr. 14. pp. 1144-1148; Discussion, p. 1148, Nov. 15, 1918. Paper read before the 85. Naturforscherversammlung, Wien, Sept., 1918.)—Numerous measurements of the ultra-violet solar spectrum have been made by various workers to determine the extreme wave-lengths transmitted by the earth's atmosphere at different altitudes. Of the ordinary observations quoted the highest was at Monterosa, at an altitude of 4560 m., where the extreme wave-length recorded was near $\lambda 2912.1$. Recent observations by means of a specially constructed quartz and calcspar spectrograph attached to a balloon have provided records up to 9000 m., the extreme wave-length being 2896.10. The extension is thus not very much more than at moderate elevations, indicating that the bulk of the absorption takes place in the lower, denser strata. C. P. B.

619. *Planetary Motions.* M. Behacker. (Phys. Zeitschr. 14. pp. 989-992, Oct. 15, 1918.)—Shows that Nordström's gravitational theory [Abstract No. 354 (1918)], based upon the relativity principle, represents fall in a vacuum and the motion of a planet in the gravitational field of the sun in accordance with observation and with Kepler's laws. E. E. F.

620. *Extension of Faye's Theory of Planetary Systems.* E. Belot. (Comptes Rendus, 157. pp. 1874-1876, Dec. 22, 1918.)—Taking Faye's supposition that the primitive sun comprised a spherical nebulosity in which the density of successive layers varied with the radius, an analysis is given for finding the position of layers of special properties, for instance, the layer containing most matter, and the layer having max. centrifugal force. In this layer there would be a separation of the lighter and heavier constituents, and reducing the values found it appears that the radius corresponding to greatest centrifugal force would be about that of the orbit of Saturn, which would accordingly have the minimum density; it is also shown that such a system would have its maximum mass at the distance corresponding to Jupiter. C. P. B.

621. *Constants of the Solar System.* F. Olive. (Comptes Rendus, 157. pp. 1501-1502, Dec. 29, 1918.)—A table is given showing the close agreement of observation and calculation in the application of a formula connecting the mean distance of a satellite, its velocity round its primary, the mean distance of the planet from the sun, and the radius of the planet. Except in the cases of Uranus and Neptune the agreement is very good. C. P. B.

622. *Bright Hydrogen Lines in Stellar Spectra.* P. W. Merrill. (Lick Observatory Bull., No. 246.)—A description is given of a series of stellar spectrograms showing bright hydrogen lines in the H_α region, taken with the 86-in. refractor and a single-prism spectrograph. Details are also given of a special spectrum of P Cygni obtained with a 3-prism spectrograph. C. P. B.

623. *Spectroscopic Observations of Nova Geminorum at Pulkowa with the aid of Bredikhin's Astrograph.* H. B. Vojtkević-Pollakova. (Acad. Sci. St. Pétersbourg, Bull. 8. pp. 191-218, 1914. In Russian.)—The star Nova Geminorum No. 2 was observed at Pulkowa spectrographically in 1912 and 1918. Photographs of the spectrum were obtained by the Bredikhin astrograph, using an objective prism. A very large number of spectrograms were taken in the spring of 1912, when remarkable and abrupt changes occurred in the spectrum of the new star. All the spectrograms were obtained with an objective prism of 20° refractive angle, and a length of spectrum on the photographic plate between spectral lines H_β and H_α equal to 6.8 mm. In 1918, when the star had become notably weaker, another prism was used for the photographs having a refractive angle of 12° . The length of the spectrum in this case was equal to 1.8 mm., between the same lines. The focal length of the camera was 800 mm. The spectrograms were taken by H. A. Tikhoff except for two which the author obtained in unfavourable weather. In them the spectrum was remarkably faint, but certain very intensely bright lines are distinguishable. The observations commenced on March 15, 1912, about two days after the discovery of the star, the delay being occasioned by bad weather prior to that date. Characteristic hydrogen bands were present. From the autumn observations of 1918 it is judged by the author that the nebular spectrum will prevail at the present time (1918, Nov. 27). Tables are given of wave-lengths of lines measured. From the plate of March 15, 1912, it is asserted that helium lines, $\lambda 4922$ and 5016 , were perceptible, but not $\lambda 4471$. It is possible that the faint absorption bands $\lambda 4807$, 4459 , and 4579 correspond with spectral lines of calcium $\lambda 4808$, 4455 , and 4582 . The author thinks that band $\lambda 4685$ is sufficiently approximate to suggest a relationship to the known band $\lambda 4640$ relating to Campbell's nebula spectrum and observed in the spectra of Nova Persei ($\lambda 4689$), Nova Geminorum No. 1 ($\lambda 4648$), and Nova Lacertæ ($\lambda 4644$). Many faintly bright lines between H_β and K of the Pulkowa spectrogram of March 15 have been observed in the spectra of Nova Aurigæ and Nova Persei and indicate the presence of Fe, Ti, Cr, Se, and Sr. On March 17, 18, and 26, 1912, helium is again evident. In April, as in the previous month, the author noted a bright band $\lambda 5170$ ascribed possibly to magnesium. The tables cannot profitably be abbreviated. Some of the photographs are given with the article, but it is not possible conveniently to reproduce them in this Abstract. Two of these relate to March 15, 1912, the second plate being sensitive to red rays. The author remarks that on this day the continuous spectrum was very bright. On the first plate the ultra-violet end of the spectrum could be traced to $\lambda 8700$. In the region of long waves the continuous spectrum extends to H_α , as is evident on the second plate. In the region from H_β to H_α the spectrum is feeble. Many absorption bands and lines are particularly perceptible on the spectrogram of March 15. Exceedingly fine absorption lines are grouped in various parts of the spectrum which are well noted in the second plate. Very intense absorption bands are presented by $H + H_\alpha$ and K, and after these follow H_β , H_γ , H_ζ , H_η , H_θ , H_i , H_x . The last five bands are seen only on the second plate.

On March 16, 1912, the ultra-violet end of the spectrum was very strong and extended to $\lambda 8600$. The continuous spectrum was notably fainter than on the 15th. Narrow absorption lines had now widened, and, in many cases, coalesced and formed wide absorption bands, especially in the region between H_γ and H_β , characterised on the 15th by groups of fine lines. By the 8th and 4th of April the continuous spectrum was bright in the region $H_\beta - H_\alpha$, but

otherwise feeble. The ultra-violet end had rapidly weakened and the absorption bands in the region H_α — H_β had disappeared. On Feb. 11 and 18, 1918 (photograph is given for the latter day), considerable change was noticeable. The continuous spectrum gave only feeble traces between H_γ and H_α . It was sensitive also in the ultra-violet region. Separate bright bands stand out with exceptional sharpness. The relative brightness of the bands was greater than those of 1912. The prevalent hydrogen bands were now not remarkable. In Oct., 1918, weak traces of the spectrum were observed, consisting of separate bright bands. It was possible to make out bands $\lambda 5010$, $\lambda 4640$, $\lambda 4818$, and H_β . A continuous spectrum could be perceived extending to $\lambda 8790$ in the ultra-violet region. The last spectrogram was taken on Oct. 18, 1918. E. O. W.

624. Europium Lines in Stellar Spectra. F. E. Baxendall. (Roy. Astronom. Soc., M.N. 74. pp. 82–87, Nov., 1918.)—In a former note [Abstract No. 52 (1914)] it has been pointed out that special lines in the spectrum of α Canum Venaticorum obtained by B  lopolsky at Pulkowa agreed closely in wave-length with the strongest lines in the spectrum of europium. The presence of europium in celestial spectra has already been recognised by Dyson and Lunt. A search has now been made for such lines in the various photographs of stellar spectra available. The evidence is considered to confirm the presence of europium in stars of Harvard type A (pec) and A_0 ; in stars of type A_1 (pec) and F_1 it is weak and inconclusive, and in stars of type earlier than A_0 there is no evidence of its presence. C. P. B.

625. Photographic Magnitudes of North Polar Stars. S. Chapman and P. J. Melotte. (Roy. Astronom. Soc., M.N. 74. pp. 40–49, Nov., 1918.)—Determinations of photographic magnitudes of a number of faint stars in certain special regions were made for standardisation of the star-counts being made on the Franklin-Adams chart plates. Photographs of the star-field and the polar stars are made in the order pole, field, pole, each of 6 minutes' duration, giving stars down to the 18.5 magnitude with the 26-in. Greenwich refractor. Another series of plates is then taken with a diffraction grating over the object-glass, producing a series of diffracted images of each star differing by a prearranged definite magnitude-interval. The magnitudes of 262 stars within 25 minutes of arc from the pole are given in the present paper, with a drawing showing their relative positions for reference. C. P. B.

626. Photographic Stellar Photometry by Diffraction Gratings. S. Chapman and P. J. Melotte. (Roy. Astronom. Soc., M.N. 74. pp. 50–58, Nov., 1918.)—For some years past various investigators have employed coarse diffraction gratings placed over the telescope objectives for the determination of magnitude intervals. Auxiliary images are produced on either side of the ordinary central image, diverting a certain constant proportion of light into each image depending on the constant of the grating. An important advantage of the method is that the auxiliary comparison images are produced at the same time as the central ones, and are therefore independent of the constancy of atmospheric transparency, etc. Examples are given of the method of using the apparatus, and tables showing the accuracy attainable. C. P. B.

627. Radial-velocity Determinations with Prismatic Camera. M. Hamy. (Comptes Rendus, 157. pp. 81–88, Jan. 12, 1914.)—In a former paper [Abstract VOL. XVII.—A.—1914.

No. 208 (1914)] a method was proposed for employing a special form of objective grating camera for the determination of stellar radial velocities. A discussion is now given of an attempt to adopt the objective-prism form of stellar spectrograph to the same problem. The base of the prism is polished and silvered, and the prism so adjusted that while the light from a star transmitted through the glass is brought to focus as a spectrum band, the light reflected from the base is brought to focus as a simple star-image in the focal plane. Special means are described for obtaining the proper alignment of the instrument, and for photographing a comparison spectrum alongside the stellar spectrum for wave-length and velocity determinations. C. P. B.

628. *Variable Radial Velocity of 118a Piscium.* O. J. Lee. (Astrophys. Journ. 88. pp. 502-504, Dec., 1918.)—The variable velocity of this double star, having components of magnitudes 5.2 and 4.8, type A_2p , was established immediately after the second and third plates had been secured. To obviate the possibility of any influence due to the spectrum of the fainter star the images of the two were separated on the slit. The spectrum of the brighter star gives velocities from -0.8 to $+28.7$ km. per sec.; that of the fainter star gives velocities from -1.9 to $+22.9$ km. per sec. It is hoped that spectrograms with larger dispersion will be subsequently available for the study of this interesting system. C. P. B.

629. *Star Positions and Galactic Co-ordinates.* R. T. A. Innes. (Observatory, No. 470, pp. 58-64, Jan., 1914. Paper read before the S. African Assoc. for Advancement of Science, July, 1918.)—Attention is drawn to the great labour and a certain degree of uncertainty involved in the designation of star positions as at present referred to the rapidly changing datum planes in right ascension and declination. It is suggested that, in view of the standards in future being chiefly dependent on measurements of photographs of the sky, an attempt be made to adopt the galactic co-ordinates for standard catalogue positions. C. P. B.

630. *Dynamics of a Globular Stellar System.* A. S. Eddington. (Roy. Astronom. Soc., M.N. 74. pp. 5-16, Nov., 1918.)—As an introduction to the study of a hitherto uninvestigated type of dynamical system the paper gives an analysis of the dynamics of a globular stellar system. The stars are supposed to move under the central attraction of the whole system, and to be undisturbed by their immediate neighbours, and a search is made for distributions of velocity which yield a steady state for the whole system. C. P. B.

631. *Dark Regions in the Sky.* E. E. Barnard. (Astrophys. Journ. 88. pp. 496-501, Dec., 1918.)—In various regions of the sky, especially in the Milky Way, there are certain isolated regions apparently quite devoid of stars, and showing so dark on photographs as to suggest the presence of masses of absorbing material. Well-marked examples occur in the great nebulosities near the stars ρ Ophiuchi and ν Scorpii. [Abstract No. 802 (1910).] Photographs of two of these objects are reproduced with the paper. C. P. B.

632. *Influence of Atmospheric Dispersion on Stellar Photographs.* St. Chevalier. (Comptes Rendus, 157. pp. 1877-1879, Dec. 22, 1918.)—From a discussion of 1888 photographs of the sun's disc it is found that the vertical diameter is augmented by a quantity $= 0.17'' \tan z$ (z being the zenith distance of the object under observation). These results apply specially to photographs taken with an objective achromatised for G and H. C. P. B.

633. *Statistics of Star Clusters.* H. Chrétien. (Comptes Rendus, 157. pp. 1047-1050, Dec. 1, 1918.)—In applying the analysis proposed by Zeipel (*Ann. de l'Obs. de Paris*, 25) to the study of star clusters, several modifications are described which facilitate the practical study of measurements of photographs of such clusters. The results are to be applied to measures of clusters taken at Mount Wilson, California, with the 60-in. mirror. C. P. B.

634. *Changes in Tuttle's Nebula.* Borrelly. (Comptes Rendus, 157. pp. 1877-1879, Dec. 22, 1918.)—This remarkable nebula was discovered by Tuttle in 1859, and was specially observed in 1862 by D'Arrest; later also by Argelander, Auwers, and Bigourdan. All of these observers describe it as of about the tenth magnitude. From observations during the period 1889 to 1907 it appeared to diminish sensibly, and the brightness had apparently decreased so much by July, 1913, that it is recorded as being scarcely perceptible, probably not more than 11.5 magnitude. It is thought there is evidence of real changes in the brightness of the nebulosity. C. P. B.

635. *Calculation of Circular Orbit from One Photograph.* L. Picart. (Comptes Rendus, 157. pp. 1508-1505, Dec. 29, 1918.)—A method is outlined whereby, by measuring the length of trail of a planet and its direction on a photograph showing standard stars, it is possible to determine the elements of a circular orbit with sufficient accuracy to ensure the recognition of the object. The procedure would be of special utility in the observation of minor planets. C. P. B.

LIGHT.

636. *An Immersion Ultramicroscope.* R. Zsigmondy. (Phys. Zeitschr. 14. pp. 975-979, Oct. 15, 1918.)—Describes an improved ultramicroscope of greater illuminating power, obtained by increasing the apertures both of the illuminating and the observing objectives. The objectives preferred have a focal length of 6 mm. and a numerical aperture 1.05. The front lens is of quartz, with an over-hemispherical surface, bearing in front a conically ground piece of quartz. The advantages claimed are a shortening of the path traversed by light in the observed substance, the possibility of working on a single drop of liquid, or the reduction of the vessel to the smallest dimensions. Gold and silver particles may be photographed even without retarding their Brownian motion by means of gelatine. E. E. F.

637. *Spectrograph.* C. Leiss. (Phys. Zeitschr. 14. pp. 978-975, Oct. 15, 1918.)—A description of a high-luminosity spectrograph for the visible region, in which a simple lens is used instead of a photographically corrected camera objective. The aperture of the collimating lens is F/4, and that of the camera lens F/6, with a free diam. of 4 cm. The dispersing body is a Rutherford prism. No part of the instrument is made of wood. For the photography of spark spectra, with a spark-length of 8 cm., at a distance of 10 cm. from a slit 0.02 mm. wide, the exposure is about 2 to 3 minutes for mean wave-length. E. E. F.

638. *Leitz's New Binocular Microscope.* F. Jentsch. (Phys. Zeitschr. 15. pp. 56-62, Jan. 1, 1914. Roy. Microsc. Soc., Journ. pp. 1-16, 1914.)—A single objective is used, and the light after passing through this is partly reflected and partly transmitted through a semi-transparent layer of silver on one face of a reflection prism. The resulting two beams are by means of other prisms caused to enter the two eyepiece tubes of the instrument. The prisms are so arranged that the two beams have the same length of path in glass. The arrangement has a certain stereoscopic effect, which is discussed. A. W.

639. *Radiometer for a Monochromator.* W. W. Coblentz and C. Leiss. (Zeitschr. Instrumentenk. 84. pp. 14-18, Jan., 1914.)—A description is first given of the Bi-Ag thermo-element, 22 to 24 couples being used, and the alternate junctions being arranged in a vertical line, each junction in this line being attached to a small silver plate of dimensions $2 \times 0.7 \times 0.025$ mm.; these plates are coated with platinum- and lamp-black. Diagrams are given of the complete arrangement for use with a Fuess monochromator, the thermo-element being contained in an evacuated chamber. A. W.

640. *Adjustment of Telescope by Auto-collimation.* G. Lippmann. (Comptes Rendus, 158. pp. 88-91, Jan. 12, 1914. Journ. de Physique, 4. Ser. 6. pp. 97-100, Feb., 1914.)—A delicate device is described for the exact auto-collimation of telescopes by the reflection method. A very fine slit produced by a diamond scratch on a silvered glass plate is illuminated by the light source, the light then passing on to the objective under test and the

reflecting surface, generally a bath of mercury, from which it is sent back towards the slit. The glass plate bearing the slit is put at 45° to the axis of the objective, and the fine slit viewed with an eyepiece. In most cases it will be found that the reflected image of the slit is visible near the slit itself, but it will be then possible by means of a fine micrometer screw to adjust matters so that the image just returns through the slit, and nothing is visible in the eyepiece. As an example of the accuracy attainable, it was found possible, with an objective of 2 m. focal length, to set the slit in collimation to about 1.5μ , corresponding to about $0.15''$ of arc.

C. P. B.

641. *Refractive Indices of Liquid Crystals.* W. Kreide. (Phys. Zeitschr. 14. pp. 979-981, Oct. 15, 1913.)—Determines the refractive indices of cholesteryl chloride and nitrobenzoate for the red Li line, the D lines, and green and blue Hg lines. The results are given in curves for various temperatures. In the second substance the liquid-crystalline phase extends from 141° to 77° C.

E. E. F.

642. *Media of High Refractive Power for Photomicrography.* C. Jones. (Photographic Journ. 54. pp. 14-25; Discussion, pp. 25-26, Jan., 1914.)—A paper dealing in detail with various media of high refractive power. These include styrax, liquidambar, monobromnaphthalene, piperine and mixtures of piperine, and media containing arsenic and sulphur. Styrax requires first hardening by being kept warm for a considerable time, but the ordinary subsequent treatment may be modified by dissolving the hardened styrax in only about its own bulk of benzene and filtering the syrupy solution through ordinary filter-paper, when it is at once ready for use. Liquidambar, stated by Van Heurck to have a rather higher refractive index than styrax, may be treated in exactly the same way. Monobromnaphthalene, a liquid with an index of 1.66, is very convenient for temporary use. Piperine has an index of 1.68, and is easy to use, since it melts at 128° C. to a thin watery liquid. In small thicknesses it is free from colour. Fused piperine begins to go opaque because of crystallisation in about a month, but the process of crystallisation is slow in a microscope slide, slides prepared with piperine showing a considerable area in good condition several months after preparation. If the piperine is first heated for an hour to 180° C. it is found that after the lapse of 2 years crystallisation has not started. Piperine has a high dispersive power in addition to its high refractive index, which latter is given by Madan as 1.710 for the E-line and 1.788 for the F-line. For some purposes the high dispersive power may be advantageous. A slide made in 1891 with a mixture of piperine and antimony bromide is in perfect condition still, but one made in 1889 with a mixture of arsenious bromide and piperine has gone nearly opaque at the extreme edge, though a large portion is still in good condition. A lengthy discussion is given of media containing arsenic and sulphur, various methods of treatment being noted. The chief troubles that attend the use of pure realgar (As_2S_3) are the high temperature necessary, the cracking, and the separation from the glass; to avoid these sulphur is added to it. Research showed that a mixture of 7 parts As with $22\frac{1}{2}$ to 30 parts S was satisfactory. With less sulphur the mountant cracks and comes away from the glass; with more sulphur there is a tendency to crystallise, which is more marked the greater the proportion of sulphur. The methods of purification, and of mounting with these As-S media are described. Arsenious bromide is not recommended. The selenium-sulphur mixtures described by Merwin and Larsen [Abstract No. 1680 (1912)] are also dealt with.

A. W.

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643. Double Refraction of Metallic Films obtained by Kathodic Deposition. **C. Bergholm.** (Ann. d. Physik, 48. 1. pp. 1-23, Dec. 81, 1918.)—A glass plate introduced into a discharge tube and arranged with its plane perpendicular to a leaf-shaped kathode receives, when the discharge takes place, a wedge-shaped metallic film, symmetrical with respect to the kathode, and this film is doubly refracting. The double refraction of such films was investigated for different-coloured light, the metals used for kathode being Ag, Pt, Pd, Bi, Cu, and Au. A theoretical discussion is given. A. W.

644. Michelson-Morley Experiment. **J. Rose-Innes.** (Phil. Mag. 27. pp. 150-153, Jan., 1914.)—To explain the negative results of the above experiment Fitzgerald put forward his hypothesis of the contraction along the line of motion. But this contraction has not been directly observed. The failure to confirm this contraction led to the theory of relativity, in which, with a good deal of metaphysical subtlety, all our notions of time and space are revised.

It seems to have been overlooked that a third solution is possible, viz., that, even though there be no dragging effect, such as Lodge searched for, a change in the constants of the ether may perhaps take place, owing to the motion of a large mass in the neighbourhood. Thus at the surface of the earth the ether may be supposed to alter slightly in its properties, owing to the orbital motion. It may be imagined that the velocity of an ethereal disturbance parallel to the motion of the earth is unaltered, but that at right angles to the orbital motion the velocity of a disturbance is $V - u^2/2V$, where V is the velocity of light in free ether, and u is that of the earth in its orbit. Any other simple function of V and u agreeing with the above as far as squares of small quantities would, of course, answer the purpose equally well in the present state of our experimental knowledge.

The correction-term suggested above is applicable to measurements at the surface of the earth; at considerable distances from the earth the effect of its motion ought clearly to be taken as smaller. Allowance for this falling-off in the effect is made by supposing that the correction is more nearly represented by an expression of the form $u^2/2V \cdot (1 - e^{-G})$, where G is a function of the mass and the distance, akin to gravitation, in so far as it is large in the neighbourhood of massive bodies and becomes small as the masses are smaller or the distances greater.

There is an imaginary experiment worth noting which would give different results according as we adopted the present theory or that of relativity, and which might therefore serve as an *experimentum crucis*, could the experimental difficulties be removed. If one could detach Michelson and Morley, together with their apparatus, from the earth and send them travelling along at the rate of 19 miles per sec. in the free ether, the absence of the earth would make no difference according to the theory of relativity, but would cause a displacement of the fringes according to the present theory. There are, however, very grave difficulties in the way of the actual experiment, and it will be some time before they are overcome. E. H. B.

645. Diffraction of Light by Particles Comparable with the Wave-length. **B. A. Keen and A. W. Porter.** (Roy. Soc., Proc. Ser. A. 89. pp. 370-376, Jan. 1, 1914.)—This research was undertaken to investigate an effect noticed when experimenting with the light scattered by suspensions of finely-divided sulphur. These were obtained by depositing sulphur from a solution of sodium thiosulphate by means of a weak acid. When such a suspension is

placed in the path of a beam from an arc lamp focused on a screen, the image of the carbon is usually red, of greater or less depth according to the size and number of the diffracting particles. The explanation of this has been given by Rayleigh. But if time be given for the particles to increase in size, and possibly in number also, the solution after becoming nearly opaque becomes transparent again, and in this new stage an excess of blue is transmitted, which attains at one stage a deep indigo tint, this afterwards changing through various blue-green and green tints to white. Analogous phenomena have been observed by Abney and Ritz, and show that the phenomenon is not peculiar to sulphur. The research consisted of measuring, at various instants after setting free the thiosulphuric acid, the transparency of the suspension to monochromatic lights of various wave-lengths. For this purpose a Hüfner spectrophotometer was employed. Light passing first through a fixed nicol, and then through one which can be rotated, is matched with light passing through the solution and the second nicol. On its way the light is sorted into its constituent colours by means of a constant-deviation prism; the match can therefore be made for any desired colours in succession. Particular care had to be taken with regard to temperature and stirring. Two typical wave-lengths—one in the blue and the other in the red—were selected, and the complete experiment was performed with one wave-length at a time. The gradual change of the transmitted light from red through blue to white is plainly shown by the curves obtained for the two colours. In the first stages of the reaction the intensity of the blue light falls off more rapidly than the red. At the end of about 8 minutes the blue light reaches its minimum and begins to increase, while the red light is still falling to its minimum. The transmitted light—when due allowance is made for the rest of the spectrum—becomes a purple colour. After the curves cross the blue end of the spectrum predominates, and hence we get the blue colour of the transmitted light, which gradually changes to white as the remaining rays increase in intensity. The minimum and final intensities are the same for each wave-length. The transmitted intensity may be represented by a function of t/λ , where t is the time. With regard to the relation between the diam. of the particles and t more difficulty exists, and further mathematical treatment than that given by Rayleigh is needed, for the size of the particles in the present experiments was considerably greater than those treated by Rayleigh. The growth of the particles is very sensitive to temperature-changes. Some results obtained at about 2° C. did not show the drop and subsequent rise in the intensity of the transmitted light that were obtained at higher temperatures. A. W.

646. *Theory of Moving Mirror.* II. A. Harnack. (Ann. d. Physik, 48. 2. pp. 295-308, Jan. 28, 1914.)—The second part of a mathematical discussion of this subject in which the results to be expected under various forms of relativity are examined. It is finally concluded that under the conditions here laid down it is impossible for the speed of light to be influenced by the moving mirror. [See Abstract No. 402 (1918).] E. H. B.

647. *Optical Electrons and Ions.* K. Kilchling. (Phys. Zeitschr. 15. pp. 88-98, Jan. 15, 1914.)—An analytical and numerical paper of which the following are the chief results:—1. A new calculation of $p \cdot e/m$ in the ultra-violet on the basis of the improved dispersion data is carried out for fluor-spar, rock-salt, sylvine, and quartz. 2. The Thomson dispersion theory is extended by the addition of damping forces in the region of anomalous dis-

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persion, and this development applied to the calculation of $p \cdot e/m$ for the infra-red. 8. For rock-salt, sylvine, fluor-spar, and quartz, $p \cdot e/m$ is calculated for the dispersion data in infra-red, for water from the absorption curve.

E. H. B.

648. Intermittent Vision. A. Mallock. (Roy. Soc., Proc. Ser. A. 89. pp. 407-410, Jan. 1, 1914.)—The spokes of the wheels of passing motor-cars often appear momentarily stationary, and sometimes even seem to be turning in the direction opposite to their actual motion. These appearances, lasting only for a small fraction of a second, coincide with the steps of the observer, and are only noticeable when the speed of the vehicle lies between certain limits. The motion must be too quick for the eye to follow the individual spokes, and must not exceed a certain limit, which is slightly different for different individuals. The effect was examined by using a disc of black paper with 12 equally spaced radial white lines on it. This was spun on a top, which lost its speed slowly. It was found that the lines on the spinning disc appeared stationary not only at each step, but that any slight mechanical shock, such as is given by gently tapping the head, was equally efficacious. With the speed so low that only 9 or 10 lines passed a fixed point in a second the appearance was merely that of ordinary flicker, and when 80 or more lines passed in the same time the surface looked uniformly grey; in both cases mechanical shock had no apparent effect. The impressions received at intermediate stages are described and diagrams given. An explanation of the phenomena can be given on the assumption that a slight mechanical shock of any kind produces a periodic but rapidly extinguished paralysis of the perception of light. Such an explanation is suggested. A. W.

649. Bending of Plane Waves for any Position of the Incident Plane with Respect to the Bending Edge. A. Wiegrefe. (Ann. d. Physik, 42. 6. pp. 1241-1256, Dec. 28, 1918.)—Mathematical.

650. On the Luminosity Curve of a Colour-blind Observer. W. Watson. (Roy. Soc. Proc, Ser. A. 89. pp. 86-88, Aug. 1, 1918.)

651. Absorption by Sodium Vapour mixed with Neutral Gases. K. Fredenhagen. (Phys. Zeitschr. 14. pp. 1047-1049, Nov. 1, 1918.)—Experiments made by mixing helium with Na-vapour show a difference of absorption which is, however, not due to any influence of the neutral gas on the aggregation of the Na-atoms, but solely to the difference of density of Na-vapour produced by dilution. E. E. F.

652. Ultra-violet Absorption of Acetone. H. T. Clark and A. W. Stewart. (Phys. Zeitschr. 14. pp. 1049-1050, Nov. 1, 1918.)—Photographic absorption measurements with pure acetone show the presence of an absorption band in the ultra-violet whose less refrangible edge lies at $886.5 \mu\mu$. The transmission curve does not show a minimum, but it shows at all events a point of inversion at that wave-length. J. Stark adds a note drawing attention to the theoretical importance of this new band. E. E. F.

653. Wave-length Standards. L. Janicki. (Zeitschr. wiss. Phot. 18. pp. 178-185, Jan., 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—Gives particulars of the determination of a number of third order VOL. XVII.—A.—1914.

normal wave-lengths in the arc spectrum of iron between $\lambda 4282$ and $\lambda 4908$. The results are tabulated and compared with those of Burns, Goos, and Kayser. [See Abstracts Nos. 866 (1912), and 1481, 1482, 1486 (1918).]

654. *Standard Wave-lengths of Iron Spectrum.* C. E. St. John and L. W. Ware. (Astrophys. Journ. 89, pp. 5-28, Jan., 1914. Mount Wilson Solar Observatory, Contributions, No. 75.)—A revised list is given of 198 lines in the spectrum of iron between $\lambda 4118$ and $\lambda 5506$, determined from photographs taken with the 75-ft. Littrow spectrograph of the Tower telescope at Mount Wilson. Variations in wave-length of certain lines as determined at Pasadena, at the foot of the mountain, and at the top of the hill are ascribed to pressure effects. C. P. B.

655. *Classification of Spectra.* F. Croze. (Journ. de Physique, 8. Ser. 5. pp. 882-900, Nov., and pp. 962-970, Dec., 1918.)—Research is here discussed relating to the classification of spectra according to their structure and their magnetic variations. In the spectra of series lines, the Zeeman-effect presents itself as a normal triplet, not only for the series of single lines, but also for the series of doublets and triplets for fields above a certain value. Observations with hydrogen show that, to obtain concordant results, the phenomena must be investigated under conditions where the electric discharge is not modified by the magnetic field. Study of the Zeeman-effect has not yet resulted in the discovery of the laws of distribution in the spectra of non-series lines. In the case of pure triplets, however, special values are found, and for more complicated decompositions certain similarities are noted. Recent researches on band spectra tend towards the conclusion that the emission bands of gases and vapours are all resolvable, and constituted of series of lines which start from one or many heads and whose law of formation is to a first approximation similar to arithmetic series. The study of the action of magnetic fields permits band spectra to be divided into two classes: those which show the Zeeman-effect and those which do not. Among the latter, all those which have been investigated up to the present in intense fields have their lines slightly displaced by the field in a manner which varies from one series to another, but always in the same way for the same series. With regard to the others, which show the Zeeman-effect, identical separations are found for the heads of any particular series. These facts show that the distribution into series has a true physical significance. In the case of complex spectra like the second spectrum of hydrogen, a systematic study of the Zeeman-effect enables the lines belonging to bands to be separated from those belonging to a line spectrum. Possibly further light may be thrown on the subject by using still larger fields than those employed, of the order of 40,000 gauss. A. W.

656. *Positive Band Spectrum of Nitrogen.* R. T. Birge. (Astrophys. Journ. 89, pp. 50-88, Jan., 1914.)—This paper is a preliminary discussion of the first Deslandres' group of the positive band spectrum of nitrogen, based mainly on photographs taken in the second order of a 21-ft. concave grating, from $\lambda 5000$ to $\lambda 6800$. A complete discussion of previous work, together with research on the long-wave portion, has been given by von der Helm [see Abstract No. 1485 (1910)]. The results of the present discussion are as follows:—The first Deslandres' group consists really of two spectra, one composed of a large number of superimposed series of lines, the other quite irregular. The similarity in the spacing of all series gives the banded

appearance of the spectrum, the length of a band being the distance between two successive lines of each series. The so-called heads of the bands are formed by groups of particularly heavy lines, accompanied by more or less continuous radiation. It is possible to fit a greater number of lines into the simple series of the von der Helm arrangement of bands than into the more complex two-parameter formula indicated by the Cuthbertson arrangement. All physical changes in the spectrum, however, favour the latter arrangement. Simple series of lines, running through one band group of the von der Helm arrangement obey Deslandres' law for at least the first few bands, but later show a large and systematic deviation from it. The first and second progressions of the Cuthbertson arrangement fit approximately into a formula containing both the second and third powers of the parameter, but will *not* fit the simpler second-power formula of Deslandres' law. The successive band groups have certain heads which approximately coincide, and these points of coincidence show regularities which enable the entire set of bands of the first Deslandres' group to be arranged so as to indicate a definite plan for the group. The 89 bands between $\lambda 5000$ and $\lambda 6800$ were resolved into about 6400 lines, a portion of which have been measured with an average error of 0.01 \AA. or less.

A. W.

657. *Second Spectrum of Neon.* T. R. Merton. (Roy. Soc., Proc. Ser. A. 89. pp. 447-451, Jan. 1, 1914.)—Neon when subjected to a jar discharge of small intensity is found to exhibit a spectrum in the more refrangible region entirely different from the ordinary spectrum. The lines of the ordinary spectrum in the orange and red appear much weaker, while the new lines developed and measured down to 8218 \AA. have a very considerable intensity and can be observed through the glass of the capillary tube. The lines are measured with a grating spectrograph and the measurements are probably accurate to 0.1 \AA. In all cases they correspond closely to lines found by Liveing and Dewar [Abstract No. 1794 (1908)] in the spectrum of the gases of the atmosphere which are not condensed at the temperature of liquid hydrogen. On the other hand, only about one-half the number of lines, apart from those which belong to the spectra of hydrogen and helium, observed by Liveing and Dewar have been recorded, and this deficiency is attributed to the weak illumination afforded by the concave grating as compared with the calcite prism spectrograph used by the last-named workers.

C. S. G.

658. *Spectra of High-frequency Discharges in Geissler Tubes.* R. W. Lawson. (Phil. Mag. 26. pp. 966-981, Dec., 1918.)—The author has undertaken the following investigation owing to the fact that a variety of spectra can be obtained with many elements according to their mode of electrical excitation. It is therefore desirable to examine spectra obtained by different methods, as such a procedure may greatly assist in the determination of the underlying causes for the production of one or other of the spectra of the element concerned. In the case of vacuum tubes the pressure of the gas, its temperature and purity, the current density and voltage employed, are all known to influence the character of the discharge, but in a way not clearly understood. In the present work the source of current was the Poulsen arc. A detailed description of the apparatus used is given. For the photography of the spectra obtained, a Hilger fixed-arm spectrograph was used, while a Kelvin electrostatic voltmeter was employed for the measurement of voltage across the discharge tube. The discharge current was measured by passing

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it through a fine Pt-wire, which heated a copper-constantan thermo-couple, and the resulting e.m.f. was registered on a Paul single-pivot galvanometer. An induction coil was kept conveniently near the discharge tubes, so that the discharge as obtained by the Poulsen generator could be compared with either the condensed or the uncondensed induction-coil discharges. The frequencies of discharge were also obtained by means of a portable wave-meter standardised by a Fleming cymometer. Various methods of direct and inductive coupling were employed between the generating and discharge circuits, and two which were found particularly suitable are described. Whilst it was readily possible to obtain feeble discharges similar to those obtainable using an induction coil, the majority of the discharges from the Poulsen generator were of extraordinary brightness. The advantage of this lay in the fact that very short exposures were necessary, and therefore greater average constancy of discharge conditions maintained for those short intervals. Since the form of the bulb discharge was found to vary greatly according to the pressure and current in use, general descriptions of this for the different gases are given. In none of the cases examined was the frequency of the discharge found to have any influence on the spectrum obtained, this being the same at lower and higher frequencies, other conditions being maintained constant; also no matter how the current and voltage were adjusted was it found possible to produce the condensed discharge spectrum by means of the Poulsen generator. That the oscillatory character of the condensed discharge is the determining factor for the production of the elementary line-spectrum of a gas is thus an untenable suggestion, and it seems probable that the production of the line-spectrum of a gas by use of condenser and spark-gap is dependent on the initial value of the current in the discharge tube at each train of oscillations. The observations made on the different gases are fully recorded.

An interesting method is described for obtaining a steady stream of nitrogen, since the usual methods give a spasmodic and somewhat violent evolution of gas. Briefly this consists in passing a stream of pure chlorine through strong ammonia solution whereby nitrogen, hydrochloric acid, and ammonium chloride are liberated. The latter are removed by repeated washing in air-free water, then passing over solid caustic potash, and, after bubbling through concentrated sulphuric acid, the pure nitrogen is collected over mercury. Photographs are given of nitrogen, air, hydrogen, and argon under the varying conditions outlined above, together with detailed description of the different spectra obtained. Variation of current density and voltage in the discharge tube with internal or external electrodes did not produce any change in the relative intensity of the nitrogen bands in the capillary, but considerable differences are recorded with pressure-changes. In the case of air no oxygen lines were discernible, the spectrum being the same as that of pure nitrogen under every circumstance. The negative-glow discharge in Geissler tubes with internal electrodes failed to show any trace of the spectra of oxygen. Hydrogen was prepared by the electrolysis of an air-free solution of baryta in water, and after bubbling through strong sulphuric acid was collected over P_2O_5 . At constant frequency, the series spectrum of hydrogen was greatly enhanced relatively to the secondary or many-lined spectrum when larger current values were used: a similar result to that obtained with increased currents in hydrogen when the induction-coil discharge is used. The appearance of the tube, particularly with the Poulsen discharge, is very striking. At low currents the tube has somewhat of a bluish-lavender colour, whilst at high currents it glows very strongly with a strong ruddy glow.

With gradually increasing current-values the secondary spectrum appeared to increase uniformly, but the primary spectrum showed marked selectivity, the α , β , and γ lines increasing in descending order of magnitude respectively. At higher pressures the external electrode bulbs were rich in the secondary spectrum, but showed the primary spectrum very feebly. Oxygen was prepared by heating potassium permanganate in a glass tube sealed on to the apparatus, a previous heating in an oven at 110° C. for 48 hours being found to remove all moisture. Under all the conditions of voltage, current, and gas-pressure available, the compound line-spectrum was alone obtainable at ordinary temperatures.

Argon, possessing three different spectra, is a particularly suitable gas to test under the conditions of these experiments. The red spectrum is that usually produced by use of the uncondensed induction-coil discharge, the blue by the condensed discharge, while the white is the result of mixed conditions. The author discusses previous work on these spectra. Using the Poulsen generator it appears likely that the initial value of the discharge in each train rather than the mean value of the current determines the spectrum produced; and since the complete transformation from the red to the blue spectrum was obtained by use of a constant-frequency undamped discharge with increasing current values, the author concludes that current density is the main determining influence. With neon, He, and CO the spectra were identical with those obtained when using the induction-coil discharge without condenser. H. H. Ho.

659. Zeeman-effect in Series Spectra of Oxygen and Hydrogen. F. Croze. (Comptes Rendus, 157. pp. 1061-1068, Dec. 1, 1918.)—Paschen and Back have studied the Zeeman-effect for the triplet 8947 ($\Delta\lambda = 0.298$; $\Delta n = 1.88$ cm./sec.) of the principal series of oxygen, and for the lines H_{α} and H_{β} of the first subordinate series of hydrogen, which they consider as doublets ($H_{\alpha}\Delta n = 0.82$) [see Abstracts Nos. 419 and 1282 (1918)]. Their results are in disagreement, both qualitative and quantitative, with the results of Croze [Abstracts Nos. 1867 (1912) and 420 (1918)], who always found, in fields up to 24,000 gauss, for each of the lines H_{α} , H_{β} , H_{γ} , H_{δ} , a pure triplet of normal polarisation and normal separation. In Paschen and Back's experiments, however, the discharge tube was arranged perpendicular to the axis of the electromagnet; while in those of Croze the tube was arranged parallel to the axis of the magnet. Croze has now repeated his experiments and also those of Paschen and Back. The results for the oxygen triplet 8947 show that it exhibits the same behaviour whether the tube is parallel or perpendicular to the axis of the electromagnet: the results are in perfect agreement with Paschen and Back's observations. Agreement was also obtained for the hydrogen lines when the tube is perpendicular to the axis of the magnet, but in the case where the tube is parallel to the axis of the electromagnet, with fields ranging from 9000 to 21,000 gauss, the line H_{α} was always found to give a triplet with normal polarisation and separation. It should be noticed that when the discharge tube is arranged perpendicular to the direction of the magnetic field, the discharge is much altered in character. The cause of this alteration is being investigated.

A. W.

660. Ultra-violet Bands of One-, Two-, and Three-atomed Oxygen Molecules. J. Stark. (Ann. d. Physik, 48. 2. pp. 819-886, Jan. 28, 1914.)—The research here described shows that the O_2 -molecule gives rise to the emission of numerous bands extending from the green to about $\lambda 2100$, the bands shading

off towards the long wave-lengths and being resolvable into lines. The O_2 -molecule gives rise to short-waved bands, resolvable into lines, in the region $\lambda 2000$ to about $\lambda 1850$, which correspond exactly with the ultra-violet fluorescence band of oxygen. The so-called ultra-violet water-vapour band extending from $\lambda 8400$ to $\lambda 2800$ is found to belong to the O-molecule. It is found to be emitted strongly in pure oxygen in the positive column, and in such compounds containing oxygen as may at low temperatures give rise by dissociation to single O-atoms. A. W.

661. Electromagnetic Theory in Relation to the Magnetic Effect on the Canal-ray Spectrum of Hydrogen. W. Wien. (Preuss. Akad. Wiss. Berlin, Ber. 4. pp. 70-74, 1914.)—The development of the quanta theory has called into question the validity of Maxwell's theory and its fundamental equations. Of these the equation of the force acting on an electric charge, $f = E + 1/c(vH)$ has been verified for simple cases by the Zeeman phenomenon, but Einstein's deductions from the relativity principle have questioned its general accuracy [Abstract No. 2277 (1905)]. The recent work of Stark has demonstrated the resolution of spectral lines by an electric field (E), and if the equation be written $f = 1/c(E_m + vH)$ it follows that by choosing a suitable magnetic field and using the rays of hydrogen, vH can be made equal to E and an effect similar to that obtained by Stark should result.

The observed broadenings of H_β and H_γ for a suitable arrangement are measured, and they agree in order of magnitude with the calculated amounts, but in most cases are slightly too large. More accurate experiments are contemplated. The field used is about 17,000 gauss, and the discharge voltage varies from 5000 to 14,500 volts, while the velocity, v , is measured by the Doppler-effect. C. S. G.

662. Variations of Band Spectra in Magnetic Field. H. Deslandres and V. Burson. (Comptes Rendus, 157. pp. 1105-1111, Dec. 8, 1913.)—Examination of the spectrum of the blue-cone of an oxycoal-gas flame in magnetic fields of 9500, 17,000, 24,000 gauss resulted in the detection of a complicated series of phenomena requiring further investigation. Separation into polarised components as in the ordinary Zeeman-effect was observed; in addition special displacements, and simplifications of the doublets similar to those described by Paschen, Back, and Fortrat. *Errata* (Ibid. p. 1492, Dec. 22, 1913.) C. P. B.

663. Inverse Zeeman-effect. H. M. Hansen. (Ann. d. Physik, 48. 2. pp. 169-248, Jan. 28, 1914. Extract from Habilitationsarbeit, Copenhagen.)—Describes an elaborate investigation of the phenomena associated with the inverse Zeeman-effect of the D-lines and the red Li-line. The grating spectrograph previously described [Abstract No. 881 (1912)] was employed. The phenomena dealt with are the longitudinal circular, and the transversal linear double refraction within a magnetically dispersed absorption line. The dependence of the phenomena on the field strength and on the density of the vapour in the flame used, was investigated, the conditions being varied as much as possible. The results are discussed with relation to the theory of dispersion. A. W.

664. Maximum Separation in Zeeman-effect. K. Schwarzschild. (Deutsch. Phys. Gesell., Verh. 18. 1. pp. 24-40, Jan. 15, 1914.)—A mathematical treatment based on the theory of Lorentz. A. W.

665. Effect of Electric Field on Spectrum Lines. K. Schwarzschild. (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 20-24, Jan. 15, 1914.)—Warburg has shown [see Abstract No. 460 (1914)] that an explanation can be given, based on Bohr's model atom, of the effect of a strong electric field on the spectrum lines of canal rays. The explanation gives results in approximate quantitative agreement with the experimental values obtained by Stark. In the present paper an electron revolving about a centre is considered, and an explanation of the Stark-effect is deduced, following the ordinary laws of mechanics. The numerical results for the separation are, at any rate for the visible spectrum, of the same order of magnitude as those of Warburg.

A. W.

666. Electric Analogue of the Zeeman-effect. A. Lo Surdo. (Accad. Lincei, Atti, 22. pp. 664-666, Dec. 21, 1913; 23. pp. 82-84, Jan. 18, 1914. Phys. Zeitschr. 15. p. 122, Feb. 1, 1914.)—In attempting to study the Doppler-effect due to retrograde positive rays near the cathode by means of a tube placed obliquely or perpendicularly to the collimator of the spectroscope, the author observed that the hydrogen lines appeared to be decomposed into several elements. This phenomenon is identical with that subsequently observed by Stark [see Abstract No. 288 (1914)]. The line H_γ is decomposed into five polarised elements, the plane of vibration with the two outer ones being parallel, and with the three inner ones perpendicular, to the direction of the field. By means of a special arrangement, the light was observed along a line parallel to the electric field, and, as was to be expected, the H_γ line then shows three elements; for the exposures used by the author, which give but light impressions of the H_γ lines, the spectrogram of these lines is not subject to disturbance by the Doppler-effect of the direct and retrograde positive rays. A. Garbasso. (Phys. Zeitschr. 15. p. 128, Feb. 1, 1914.)

T. H. P.

667. Effect of Electric Field on Spectrum Lines. A. Garbasso. (Accad. Lincei, Atti, 22. pp. 685-689, Dec. 21, 1913.)—Stark has shown [see Abstract No. 288 (1914)] that the single ray emitted by an ionised gas is resolved into three or five components by the application of an intense electric field. Observations have also been made by Lo Surdo [see preceding Abstract]. The phenomenon is of great interest theoretically, since it throws new light on atomic structure. The Thomson model atom, at any rate in its original form, does not yield an explanation of the Stark-Lo Surdo effect, and from considerations here advanced it does not appear likely that the modification suggested by Voigt will improve matters in this respect. Bohr's theory applied to Rutherford's model atom, may, however, be modified to explain the effect. Calculations based on this theory give for the distance apart of the outer components of the hydrogen line H_β in a field of 18,000 volts per cm. the value of 8.1 \AA . The value found experimentally by Stark was 8.6 .

A. W.

668. Structure of Band Spectra. R. Fortrat. (Comptes Rendus, 157. pp. 991-994, Nov. 24, 1913.)—Details are given of the effect of the magnetic field on the band spectra of carbon, cyanogen, and air. [See Abstracts Nos. 1489 (1913) and 468 (1914).]

C. P. B.

669. Series Absorption Lines. C. Füchtbauer and W. Hofmann. (Ann. d. Physik, 43. 1. pp. 96-184, Dec. 31, 1913.)—A more detailed account of work previously published [Abstracts Nos. 229, 280 (1914)].

J. M.

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670. X-ray Interference Patterns. M. de Broglie. (Phys. Zeitschr. 14. pp. 994-995, Oct. 15, 1918.)—Adduces arguments against the view that the striation of the patches observed in X-ray interference patterns is due to selective reflection. The striæ of the same patches have very similar absorptions. In the symmetrical transmission diagrams the striæ are not symmetrical to the central ray, but parallel: $128\ 1'2'8'$, and not $821\ 1'2'8'$.

E. E. F.

671. Diffraction of X-rays and Crystalline Symmetry. G. Friedel. (Comptes Rendus, 157. pp. 1538-1536, Dec. 29, 1918.)—Explains why Laue could find no evidence of the anti-hemihedry of zinc blende, nor any difference in right-handed and left-handed quartz. The only symmetries which radiograms could reveal are holohedry and para-hemihedry. The author gives a table showing the possible symmetries shown by radiograms in each of the 82 forms of crystalline symmetry. Thus, in the cubic system, cubic holohedry may be revealed by crystals having either holohedry, holoaxial hemihedry, or anti-hemihedry; and cubic para-hemihedry may be shown by crystals having para-hemihedry or tetartohedry.

E. E. F.

672. Influence of the Constituents of the Crystal on the Form of the Spectrum in the X-ray Spectrometer. W. H. Bragg. (Roy. Soc., Proc. Ser. A. 89. pp. 480-488, Jan. 1, 1914.)—The author first describes the form of the spectra emitted by different antikathodes [see Abstracts Nos. 1880 (1918) and 86 (1914)]. The spectra of Os, Ir, and Pt show common characteristics: each metal emits three groups of characteristic rays upon which is superposed a general radiation. Palladium and Rh give remarkably simple and similar spectra. The lines from rock-salt (100) occur at angles 10.4° and 11.8° for Pd; 11.0° and 12.6° for Rh. The wave-length of the more intense line in the Pd spectrum is 0.576×10^{-8} cm., and in the Rh spectrum 0.608×10^{-8} cm. Nickel and Cu show two noticeable lines in each spectrum. The wave-length increases as the atomic weight diminishes, but the frequency is not found to be quite proportional to the square of the atomic weight. Relative intensities of various parts of the spectrum may be greatly altered by changing the crystal which is used in the spectrometer. It is shown that this may be ascribed to well-known discontinuities in relations between the atomic weight of an absorbing screen and its power of absorbing X-rays of a given quality. This cause operates through the absorbing action of the atoms of which the crystal is composed. The form of the spectrum is also influenced by the circumstances of its production. The characteristic rays always occur in exactly the same place, but their relative intensities with respect to one another and the general radiation are modified by such causes as thickness of glass of bulb, width of slits, general form of X-ray bulb, state of exhaustion, nature of coil, and so on.

The case when atoms in the crystal itself are such as to be relatively opaque to portions of the incident radiation is considered. The ordinary spectrum obtained when rays from a Pt antikathode fall on a rock-salt crystal (100) shows three very prominent "peaks" or lines—for convenience called A, B, and C, corresponding to wave-lengths in descending order of magnitude. When the same rays fall on a ZnS crystal (111), the peak A is very largely increased relative to B and C. The rays which constitute the A peak penetrate the zinc with comparative ease, whilst rays constituting peaks B and C are very quickly absorbed by the Zn and consequently there is little opportunity for the energy to be reflected, since the bulk of it is taken in

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other ways such as the conversion of X-ray energy into cathode-ray energy. This hypothesis is tested further by using crystals of sodium arsenate and potassium bromide. In each case it is found that when the crystal contains atoms of atomic weight greater than 40 and the radiations divide themselves between those which lie on one side of a critical point and those on the other, the spectrum also shows a sharp division at that point, being far stronger relatively on one side than on the other. On the hypothesis that the magnitude of a radiation represented in the spectrum depends upon the amount of absorption of that radiation in the crystal, it should be expected that crystals containing only light elements would be very efficient reflectors, and this is actually found to be the case (*cf.* diamond). It is pointed out that the law connecting atomic weight with the amount of scattering seems to be one of simple proportionality; that is, the amplitude of the scattered wave is proportional to the weight of the scattering atom. A comparison of the spectra obtained by reflection from the diamond and a crystal of ZnS, which have the same construction, except that the two interpenetrating lattices in the one case are composed of C-atoms and in the other of S- and Zn-atoms—two elements of different atomic weights, shows that it is the weight alone and not atomic nature that determines the amount of scattering.

E. A. O.

673. Influence of Hardness of X-ray Bulb on Interference Effects with Crystals. W. Friedrich. (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 69–78, Jan. 15, 1914.)—The bulb used was carefully regulated so as to be of constant “hardness” during the exposure. Zinc blende was used and the spots were examined with transmitted rays. The results showed that when the bulb was soft the spots corresponding to long wave-lengths were relatively stronger than when the bulb was hard.

E. M.

674. X-ray Patterns of Triple Symmetry. P. P. Ewald. (Phys. Zeitschr. 14. pp. 1088–1040, Nov. 1, 1918.)—Shows that Laue's condition for the occurrence of 12 simultaneous interference patches [Abstract No. 90 (1914)] can be derived from a cubical structure without reducing it to a hexagon. The direction cosine of an interference ray with respect to the primary ray is—

$$1 - \frac{1}{2}(h_1^2 + h_2^2 + h_3^2)\lambda^2/a^2.$$

Now if $h_1^2 + h_2^2 + h_3^2$, which determines this expression, is put $= 8n$, the above sum of squares may also be written—

$$(h_1 + h_2 - n)^2 + (2n - h_1)^2 + (2n - h_2)^2.$$

This shows that it may be divided up into three squares in two different ways. Each such distribution yields a triplet of indices, which, on account of the equivalence of the co-ordinate axes, represents 6 points. Both distributions together gave 12 points.

E. E. F.

675. Röntgen-ray Spectra. M. de Broglie. (Comptes Rendus, 158. pp. 177–180, Jan. 19, 1914.)—The author briefly describes the type of X-ray spectra obtained when a beam of rays, reflected from a slowly rotating crystal, is photographed [see Abstracts Nos. 248 and 244 (1914)]. Specimens are given of the photographs taken when beams of rays from Pt and antikathodes fall on a rock-salt crystal. A great improvement in the intensity of the spectra was observed by using rays from bulbs provided with lithium glass windows.

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The spectra are all of the same character and show bands as well as fine sharp lines. The bands vary slightly with the nature of the antikathode. They are continuous and correspond to the very penetrating portion of the beam. It is suggested that these bands may be due to the electromagnetic waves produced by the stoppage of cathode particles within the crystal. So far, temperature and magnetic field have not been observed to affect these bands. In addition to these bands a large number of sharp lines are also present in all the spectra. The following table gives an idea of the type of spectra observed; it was obtained with a Pt antikathode; the angle of incidence is $(90 - \alpha)$ and d is the distance between the parallel reflecting planes of atoms in the crystal:—

	α .	$\lambda \sin \alpha$.	$2\lambda \sin \alpha$.	$3\lambda \sin \alpha$.
Border of intense band	4° 44'	0.0825	—	—
Border of less intense band	9° 25'	0.1686	—	—
Intense line	10° 08'	0.1746	0.86	0.522
Faint line	11° 29'	0.199	0.896	—
Medium line	11° 44'	0.208	0.408	—
Medium line	12° 01'	0.208	0.410	—
Medium line	13° 00'	0.225	—	—
Very intense line	13° 46'	0.238	0.475	—
Faint line	13° 57'	0.241	0.482	—
Medium line	15° 44'	0.272	—	—
Faint line	16° 11'	0.279	—	—
Medium line	22° 11'	0.378	—	—
Medium line (possibly 2nd order)	28° 03'	0.471	—	—
Medium line (possibly 2nd order)	29° 13'	0.488	—	—
Medium line	30° 46'	0.511	—	—

E. A. O.

676. *Observation of X-ray Spectra on a Fluorescent Screen.* M. de Broglie and F. A. Lindemann. (Comptes Rendus, 158. pp. 180-181, Jan. 19, 1914.)—It has been shown by Terada [Abstract No. 1668 (1918)] that the displacement of Laue spots by rotation of the crystal can be observed on a fluorescent screen. By allowing the reflected rays from a slowly rotating crystal to fall on a fluorescent screen rotating with double the angular velocity of the crystal, the present authors were able to make visible the lines in the spectra of the beams employed. This method is, however, necessarily much less sensitive than the photographic method described in the preceding Abstract; the effects were not observed except with tubes provided with lithium glass windows. It is suggested that owing to the persistence of impressions on the retina, all the lines in a spectrum might be observed simultaneously, if the crystal were rotated rapidly, say, about 10 times per sec. It is pointed out that if the bands observed in these spectra are due to the stoppage of cathode particles, the wave-lengths corresponding to them would be useful to calculate the diam. of the central part of the atom; the existence of two bands corresponds to two concentric layers causing the stoppage of the cathode particles. Supposing the acceleration constant and the fall of potential to be 80,000 volts, the numbers $\lambda = 4.85 \times 10^{-9}$ and 9.24×10^{-9} (Cu) would correspond to a stoppage in a length 8×10^{-10} cm. and 4×10^{-10} cm., i.e. 4.5 % and 2.5 % of the atomic diam. This is of the order of magnitude of the diam. of the rings of electrons corresponding to the lines observed.

E. A. O.

677. Secondary X-rays. J. Laub. (Phys. Zeitschr. 14. pp. 992-994, Oct. 15, 1913.)—Studies the connection between fluorescence X-rays and the electrons simultaneously liberated; the secondary rays generated when X-rays of different degrees of hardness fall upon the thinnest metallic sheets; and the change in the secondary radiation with the increase in the number of sheets and the angle of incidence. The measurements were made by determining by means of an electrometer the saturation current produced by the secondary rays in an ionisation chamber. Secondary rays could be produced even with the thinnest semitransparent gold- and silver-leaf, provided the primary rays fell upon them at grazing incidence (5° to 10°). The intensity depends greatly upon the angle when a characteristic radiation is produced. Cu emits a much harder characteristic radiation than that described by Barkla. The author also found radiations characteristic of iron and zinc, and Stokes' rule applies to these. The rays of Pt and Pb belong to Barkla's L series. E. E. F.

678. Passage of X-rays through Metals. P. Knipping. (Phys. Zeitschr. 14. pp. 996-998, Oct. 15, 1913.)—Studies the bearing of microcrystalline structure of metals upon the transmission of X-rays [Hupka, Abstract No. 1829 (1913)]. In the case of Pt-foil the surface is probably formed entirely of octahedral faces. [See also Keene, Abstract No. 1965 (1913).] E. E. F.

679. X-ray Interference Patterns. E. Hupka. (Phys. Zeitschr. 14. pp. 995-996, Oct. 15, 1913.)—Ascribes the striation of interference patterns to irregularities of the mineral surface analogous to "ghosts" in gratings. E. E. F.

680. Sharpness of Röntgen-ray Interference Bands. E. Schrödinger. (Phys. Zeitschr. 15. pp. 79-86, Jan. 15, 1914.)—A mathematical paper which reaches the following results:—(1) The interference bands become wider and more diffused as the temperature rises. In the way here defined, the breadth is proportional to the absolute temperature. (2) The central intensity of an interference pattern is inversely proportional to the absolute temperature. (3) The total quantity of radiation which produces an interference pattern is independent of the temperature. [See Abstracts Nos. 626 (1913) and 266 (1914).] E. H. B.

681. X-rays and Metallic Crystals. E. A. Owen and G. G. Blake. (Nature, 92. pp. 686-687, Feb. 19, 1914.)—A lump of copper (for instance) was cut in two, and one of the pieces heated up to a high temperature and then allowed to cool gradually, the other piece being left untreated. Beams of X-rays were allowed to fall at almost grazing incidence on the two newly-cut surfaces, and the reflected beam was examined on a photographic plate. It was found that the untreated specimen gave no definite reflection. In the case of the annealed specimen, however, spots were observed on the plate, indicating that there were now present in the metal crystals big enough to reflect quite an appreciable portion of the beam. The same results were obtained whether the surfaces were highly polished or badly tarnished.

On passing beams of X-rays through various metallic crystals, e.g., antimony, zinc, aluminium alloy (50 % Al and 50 % Cu) Laue spots were observed on the photographic plates. Owing to the difficulty of procuring individual crystals of the metals symmetrical Laue patterns have not yet been obtained. The experiments show, however, that this method of investigating metallic crystals may prove very helpful to the metallurgist. E. M.

682. Ionisation in Various Compounds of Carbon, Hydrogen, and Oxygen by Homogeneous X-rays. H. Moore. (Phil. Mag. 27. pp. 177-187, Jan., 1914.)—Experiments were carried out on the ionisation produced by X-rays in compounds of light elements with a view to finding out if ionisation by X-rays is an atomic phenomenon. The results obtained by direct ionisation by X-rays gave no indication of the atomic character of the phenomenon, but they pointed out to the possibility that ionisation produced by corpuscular radiation might be atomic. Accordingly experiments were conducted to test this. The "corpuscular factor" for each of the vapours used was obtained—the corpuscular factor being the ratio of the ionisation produced in the vapour to that produced in air by the absorption of an equal amount of corpuscular radiation. On the assumption that ionisation by X-rays is effected by the liberated corpuscles, the amount of ionisation produced by the X-ray beam directly, divided by the corpuscular factor, gives in each case the amount of corpuscular radiation from the vapour, after a correction is applied for the corpuscular radiation from the hydrogen which is mixed with the vapour to bring the pressure up to atmospheric. From the values of the corpuscular radiation in the case of ether and methyl formate are deduced the "atomic" corpuscular radiations of carbon and oxygen. These are found to be 0.62 for oxygen and 0.20 for carbon. Assuming these to be the atomic corpuscular radiations of these elements when present in other compounds, and that the atomic corpuscular radiation of hydrogen is a negligible quantity, the calculated values of the corpuscular radiations in all the other compounds investigated were found to agree very closely with those observed by experiment. Hence the corpuscular radiation obeys an atomic law; the ionisation produced by X-rays is approximately atomic, because the corpuscular factor is very nearly unity in most cases.

E. A. O.

683. Absorption of β -Rays. H. Starke. (Phys. Zeitschr. 14. pp. 1087-1088, Nov. 1, 1913.)—Discusses the dependence of the absorption of β -rays as observed by means of an electrometer upon the relative positions of the preparation, the absorbing screen, and the electrometer or ionisation chamber. The apparent absorption is influenced by the secondary radiation produced by the original rays. These are best allowed for by placing the screen next the ionisation chamber and cutting off the direct β -rays transmitted by the screen. Under those circumstances only the diffused rays are effective.

E. E. F.

684. Excitation of γ -Rays by β -Rays. H. Starke. (Phys. Zeitschr. 14. pp. 1088-1087, Nov. 1, 1913.)—All the β -radiation issuing from a mesothorium preparation, then falling upon a metallic screen, excites γ -radiation of an intensity amounting to about one-thousandth of the proper radiation of the mesothorium. This figure assumes a radiation equal in all directions. The experiments only cover that portion of the γ -radiation which is not perceptibly enfeebled by 8 mm. of Al. The γ -radiation was determined from the ionisation current in a lead-covered ionisation chamber, as indicated by the charging-up of an Edelmann string electrometer.

E. E. F.

685. Registering the Emanation Content of the Soil-air at Potsdam with the Benndorf Electrometer. K. Kähler. (Phys. Zeitschr. 14. pp. 27-31, Jan. 1, 1914. Extract.)—The mean absolute value of the emanation-content, at 0 to $1\frac{1}{2}$ m. depth, for 289 days is given as 0.22×10^{-7} e.s. unit per cm^3 .
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The highest hourly mean value registered is 0.500×10^{-7} in Feb., 1911, the lowest 0.012×10^{-7} in April, 1912. The amount of radio-active emanation in the unsaturated depths of the soil-air is greatest in summer and least in winter. It seems that with stronger heating of the soil more emanation passes from the saturated to the unsaturated layers, and, consequently also, from the unsaturated layer into the atmosphere. The emanation-content of the unsaturated layer shows the same yearly fluctuations as the electrical conductivity of the air. During any one day there appears to be a double period; a chief maximum occurring at 7 p.m. and a less important one at 6 a.m.; the chief minimum occurring at midday and another shortly after midnight. The dependence on alterations in atmospheric pressure is so regular that this must be looked upon as the chief cause of variations in the emanations. In all months the highest emanation values are obtained with rapidly falling, and the lowest with quickly rising barometer. In Munich a sucking action of the wind has been noticed, the emanation-content being greater with a strong wind. The sun's rays also promote the entry of the emanation into the atmosphere.

A. E. G.

686. *Radio-activity of Japanese Hot Springs.* H. Ikeuti. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 176-180, Nov., 1918.)—Several springs were examined, and the mean emanation content per litre found to be about 100×10^{-13} curie for the water and 600×10^{-13} curie for the issuing gas. It was noticed that the emanation content of the water showed considerable fluctuations with time. The mean temperature of the springs was 45°C .

E. M.

687. *Radio-activity of the Waters of Spa.* E. Gerard and H. Chauvin. (Assoc. Ing. Éli. Liège, Bull. 18. pp. 512-554, Nov., 1918.)—All the sources show marked radio-activity. The results are given in the form of tables.

L. H. W.

HEAT.

688. Absolute Expansion of Fused Quartz down to the Temperature of Liquid Hydrogen. K. Scheel and W. Heuse. (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 1-8, Jan. 15, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—In earlier communications [see Abstract No. 639 (1908)] observations by the Fizeau method on the expansion of two specimens of fused quartz, one by Heraeus and the other by Zeiss, between -190° and $+100^{\circ}$ C. were described. These observations together with others over the same temperature-range made upon a specimen from the Silica Syndicate are tabulated, and further observations upon the Zeiss specimen down to the temperature of liquid hydrogen are described. The original apparatus is modified so as to diminish the heat conduction into the bath. With this modification the specimen could be kept at the observation temperature for an hour, during which time the fringe system did not move. The earlier observations showing a minimum length in the neighbourhood of -80° C. are confirmed, and the extended results from -190° to -258° agree well with those extrapolated from the original formula. Reference is made to a paper by C. L. Lindemann [Abstract No. 888 (1912)] in which the expansion of various metals down to low temperatures was determined by comparison with fused quartz on the assumption that the total expansion of the quartz from -258° to $+20^{\circ}$ C. was zero. The authors point out that by using the present determinations of the expansion of fused quartz the values of α/C_{∞} , the Grüneisen relation, depart from the values given by Lindemann by as much as 80 per cent. With copper and silver the values at various temperatures are in better agreement, but with Pb and Al the agreement is not so good. F. J. H.

689. Thermal Conductivity and Specific Heat of Granite and Basalt at High Temperatures. H. H. Poole. (Phil. Mag. 27. pp. 58-88, Jan., 1914.)—The paper is a continuation of the author's earlier work on the determination of the thermal conductivity of rocks at high temperatures [Abstract No. 1720 (1912)]. Modifications are described by means of which greater accuracy and ease of working are attained, the most important of these being the use of specimens of greater ratio of length to diam., an automatic regulation of the furnace temperature, and a new type of cement rendering it unnecessary to heat the specimen to a high temperature before making observations. Further measurements are made on the conductivity of granite, and show that the first heating to 500° produces a fall in the conductivity from nearly 6×10^{-8} to less than 4×10^{-8} , the value rising again to 4.7×10^{-8} on cooling. Subsequent observations show little further permanent alteration; they give a linear variation with temperature represented by the formula, $k = (4.68 - 0.00195\theta) \times 10^{-8}$. These values agree fairly well with the previous determinations, the chief difference being the straightness of the k, θ line. The initial permanent alteration in the conductivity is regarded as being due to the development of cracks on heating, arising from the unequal expansions of the mineral constituents. Experiments made with basalt show that during the first heating the conductivity rises slightly up to about 200° , this rise being followed by a small permanent fall upon further heating to

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400°, the final value being about 4×10^{-8} . Subsequent results with the same specimen show a slight rise in the conductivity from 100° up to 270°, beyond which it remains constant at 4×10^{-8} up to 600°, there being now little permanent alteration. The difference in character of the curves with basalt and granite, which difference is confirmed in the paper by an additional experiment on the relative conductivities, is attributed to a coarse system of cracks present in specimens of basalt, but not in granite, and almost certainly formed during the original cooling and contraction of the rock. These cracks partially close when the rock expands, and thus cause an increase in the conductivity. The cracking upon heating which occurs in the case of granite is almost absent in the case of the finer-grained basalt, which accounts for the absence of the large initial permanent decrease in conductivity. Measurements of the specific heats of the rocks at various temperatures are also made by carrying out observations of their rate of cooling or their rate of heating in the furnace when no current flows through the axial wire. For granite the mean values for the several series of results obtained are given by the formula: $S = 0.158 + 0.87 \times 10^{-5}\theta - 0.85 \times 10^{-6}\theta^2$. This gives a value at 56°, about 8 % lower than the value obtained by Joly with the steam calorimeter. The observations with basalt are represented by the formula $S = 0.188 + 0.265 \times 10^{-5}\theta - 0.25 \times 10^{-6}\theta^2$, which gives a value at 56° in excellent agreement with Joly's value.

F. J. H.

690. *Specific Heat of Air at Constant Pressure.* L. Holborn and M. Jakob. (Preuss. Akad. Wiss. Berlin, Ber. 8. pp. 218-219, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—An account is given of measurements made by the authors of the variation with pressure of the specific heat of air at constant pressure. The Callendar continuous-flow method is adopted. The air, which is compressed by a four-cylinder compressor driven by an electric motor, passes at air temperature into the strong-walled nickel steel calorimeter and is heated partly by an electric heating coil within, and partly by conduction from without to a temperature of 100° C. The calorimeter is surrounded by a rapidly circulating oil-bath, which is also provided with an electric heater to supply the heat conducted into the calorimeter at the cold end. This oil-bath keeps the surface of the calorimeter at a uniform steady temperature, which is determined by thermo-couples arranged over its surface; it is separated by a small air-space from a surrounding steam heater. The net heat-loss as the air passes through the calorimeter is eliminated in the usual way by taking observations with various rates of flow for the same rise of temperature. The results at atmospheric pressure are in satisfactory agreement with those of Swann and of Scheel and Heuse [Abstracts No. 1280 (1910) and No. 504 (1912)]. The variation with pressure measured up to 200 atmos. differs, however, enormously from that found by Lussana, but agrees remarkably well with that calculated by Linde's formula from recent experimental determinations of the cooling effect at various pressures.

F. J. H.

691. *Specific Heats of Air and Carbon Dioxide.* J. R. Partington. (Phys. Zeitschr. 14. pp. 969-978, Oct. 15, 1918.)—The ratio of the specific heats of air and of CO₂ as determined by Röntgen in 1878, are probably subject to a systematic error amounting to about 0.15 per cent. The author describes a new determination made by a combination of the methods of Lummer and Pringsheim and of Makower, involving the use of a Wollaston fibre 0.001 mm. in diam. and of duplicate leads. The resistance of the Pt-thermometer was

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read off by means of a string galvanometer. The results for c_p/c_v , reduced to the state of ideal gas by means of Berthelot's equation, are—

Air	1.4082	CO ₂ at 20°C.	1.8017
CO ₂ at 0°C.	1.8084	CO ₂ at 100°C.	1.2727

A list of former results obtained by other observers is also given.

E. E. F.

692. Method of Heating Vapours to High Temperatures. K. Fredenhagen. (Phys. Zeitschr. 14. p. 1047, Nov. 1, 1913.)—The vapours of alkali metals may be heated to white heat in tantalum tubes, thus avoiding the opacity produced by the vapours in glass and quartz. The tantalum tubes are heated electrically by means of a current of 70 amperes.

E. E. F.

693. Residual Rays of Long Wave-length. H. Rubens and H. v. Wartenberg. (Preuss. Akad. Wiss. Berlin, Ber. 7. pp. 169–190, 1914.)—The residual radiation from the following substances is here dealt with: NH₄Cl, NH₄Br, TiCl, TiBr, TlI. Curves are reproduced showing the position of the maxima and minima. The selective absorption of quartz for the residual radiation from a number of substances is also considered, the wave-lengths varying from 50 to 150 μ . In the last part of the paper the formula of Madelung and Lindemann for molecular proper frequency is discussed. It is shown that the formula is in good agreement with experimental measurements.

A. W.

694. Fixing the Temperature Scale between 0° and –198° C. F. Henning. (Ann. d. Physik, 43. 2. pp. 282–294, Jan. 28, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—In a previous communication [see Abstract No. 1169 (1913)] an account was given of the comparison of the readings of a number of Pt-thermometers with the hydrogen constant-volume thermometer at various temperatures between 0° and –198° C. The present paper describes the measurement by means of these thermometers of a number of fixed points within this range of temperature which are thus useful for the calibration of other Pt-thermometers. Such a calibration is necessary for low-temperature work since the Callendar formula does not hold below –40° C. and the readings cannot be represented by any simple formula. The following values were found:—

Oxygen, boiling-point at 760 mm.....	–188.01°
Carbon dioxide, boiling-point at 760 mm.	–78.52°
Mercury, melting-point	–38.89°
Ethyl ether, melting-point.....	–128.6°
Carbon disulphide, melting-point	–112.0°
Chloroform, melting-point.....	–68.7°
Chlorobenzene, melting-point	–45.5°

These temperatures refer to the hydrogen constant-volume scale, initial pressure 760 mm. Correcting to the thermodynamic scale affects the boiling-point of oxygen only, this becoming –182.97°.

F. J. H.

695. Instruments and Methods used in Radiometry. W. W. Coblentz. (Bureau of Standards, Bull. 9. pp. 7–68, March 15, 1913.)—The author presents a lengthy and exhaustive summary of the comparative advantages of

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four types of instruments: the radio-micrometer, the linear thermopile, the Nichols radiometer, and the bolometer with auxiliary galvanometer. He describes in detail the possible methods of improving the sensitiveness of the radio-micrometer, by reducing the weight of moving parts, changing the period, and placing it in a vacuum. The Rubens thermopile is found to be only about half as sensitive as a bolometer; but it can be improved by using thinner wires in a vacuum. Thermopiles are not so well adapted as bolometers for instantaneous registration of radiant energy, but their greater steadiness is an advantage for measuring very faint radiation (e.g. in the extreme infra-red and ultra-violet). Bismuth-silver thermopiles are recommended on the ground of high sensitiveness and ease of construction. The Nichols radiometer is as sensitive as a bolometer, but its swing is longer. It is well adapted for measuring weak radiation, especially for the study of infra-red energy. Reference is also made to the difficulty of "drift," and a method is described of using a storage battery to furnish a constant current and overcome this defect. Another point is the design of instruments to be entirely unaffected by external magnetic fields. Finally the author describes a special bolometric outfit which combines, in a high degree, the various requirements mentioned above.

J. S. D.

696. Permanent Combustions in Conducting Media. L. Crussard. (*Comptes Rendus*, 168, pp. 125-128, Jan. 12, 1914.)—Jougnet [see Abstract No 1172 (1918)] has given equations representing permanent combustions in a conducting medium. The author shows that it is possible to derive from the equation of conductivity a simple integral which simplifies considerably the investigations.

T. H. P.

697. Limits of Inflammability and Specific Retardation of Inflammability. L. Crussard. (*Comptes Rendus*, 168, pp. 840-848, Feb. 2, 1914.)—The author discusses the equations governing permanent combustions and the limits of inflammability [see preceding Abstract].

T. H. P.

698. Wien's Displacement Law. W. H. Westphal. (*Deutsch. Phys. Gesell., Verh.* 16. 2. pp. 98-96, Jan. 80, 1914.)—A discussion, partly mathematical, as to the derivation of this law.

E. H. B.

699. Frequency Calculations and Relations between Elastic and Thermal Constants of Solid Elements. C. E. Blom. (*Ann. d. Physik*, 42. 6. pp. 1897-1416, Dec. 28, 1918.)—The various formulæ for the atomic frequency which have been put forward by Einstein, Lindemann, Alterthum, and Benedicks are discussed, and then the conditions sought under which the frequencies obtained from the various formulæ all become equal. In this way certain relations between the elastic and thermal properties are obtained; for these reference must be made to the curves given in the original paper.

L. H. W.

700. Brownian Movements in Radiation Field. A. D. Fokker. (*Phys. Zeitschr.* 15. pp. 96-98, Jan. 15, 1914.)—An analytical treatment from which it is concluded that a body, by the partition of energy supplied by radiation, acquires less than when it receives it by direct mechanical interchange.

E. H. B.

701. Canonical Equation of State for Solids, K. Eisenmann. (*Deutsch. Phys. Gesell., Verh.* 16. 1. pp. 41-56, Jan. 15, 1914.)—An analytical discussion

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on the basis of the Planck-Einstein expression for the energy of a solid body $L = h\nu(e^{h\nu/kT} - 1)^{-1}$, the Boltzmann conception of entropy $S = k \log W + \text{constant}$, and the quantum hypothesis. An equation is obtained which simplifies to van der Waals' equation for sufficiently high temperatures. [See Abstract No. 885 (1918).] E. H. B.

702. *Quanta Theory of Gases.* M. Planck. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 187-145, 1918.)—That the hypothesis of quanta has a significance for the mutual action of ponderable molecules may be concluded from the fact that the specific heat of condensed bodies decreases indefinitely with falling temperatures, whereas the compressibility retains a finite value. A severe test of the hypothesis may be looked for in the domain of the kinetic theory of ideal monatomic gases. If the temperature is sufficiently low, the gas behaves as an ideal gas even when saturated. The equation for the tension of saturated vapour is $\log p = -r_0/KT + \frac{1}{2} \log T + \log [(2\pi m)^{3/2} (k^{5/2}/eg)]$, where r_0 is the molecular heat of vaporisation at temperature zero. The last term is Nernst's "chemical constant." According to Sackur and Tetrode [Abstracts Nos. 880 and 1018 (1918)], $g = h^3$ where h is the action constant. The author deduces a law of emission of vapour, and shows in a provisional manner how it may be connected with the assumption that an atom only leaves the surface when its energy is a whole multiple of $h\nu$ ($\nu = \text{frequency of vibration}$). E. E. F.

703. *Inversion Point for Liquid CO₂.* A. W. Porter. (Roy. Soc., Proc. Ser. A. 89. pp. 877-878, Jan. 1, 1914.)—In a recent paper by Jenkin and Pye [Abstract No. 1849 (1918)] observations of the Joule-Thomson effect for liquid CO₂ are given for various temperatures, and these show an inversion point at -28°C . This result is remarkable, as it implies that liquid CO₂ in this region behaves as a perfect gas. As, however, the results may be affected by the presence of traces of air, a new test for the inversion point is suggested, viz., that the ratio of the specific volume to the absolute temperature at this point should be either a maximum or a minimum. From the values of the specific volume at various temperatures and pressures given by Jenkin and Pye it is shown that a minimum value for v/T exists in the neighbourhood of -24°C ., thus confirming the result found by direct experiment.

F. J. H.

704. *Radiation and Free Electrons.* J. H. Jeans. (Phil. Mag. 27. pp. 14-22, Jan., 1914.)—There is now very general agreement that for a system of matter and ether to give Planck's formula for the radiation in its final steady state, the motion of the system must be in some way different from that predicted by the classical laws of dynamics as summarised in the principle of least action.

The problem of finding a new system of laws which shall lead to Planck's formula is as yet unsolved. In our present state of knowledge the problem is largely one of guessing, and the lucky guess has not yet been made. On the other hand, a problem which admits of scientific and ordered treatment is the following: to examine at what exact point or points it is necessary to break with the old dynamics in order to obtain Planck's formula for the final partition of radiant energy. (1) There is nothing incompatible with Planck's formula in the classical laws of propagation of light in free ether. (2) There is nothing incompatible with Planck's formula in the classical laws of thermodynamics as applied to radiant energy and the ideal walls such as are imagined

in thermodynamics. The attempt is then made to test the formula as applied to real matter. The simplest system of real matter which can be imagined is a single electron. And the author accordingly examines whether there is anything inconsistent with Planck's law in the classical laws of interaction between radiant energy and a single free electron. This is then treated mathematically.

The definite result then seems to emerge, that the departure from the classical mechanics is to be looked for in the fundamental equations of ether and electricity. Nothing so complicated as the structure of matter appears to be involved. It is not a question of modifying one's ideas on the build of atoms or molecules, but rather that we are called on to revolutionise views which have long been regarded as well established on the nature or meaning of electricity, the ether, or radiation. [See next Abstract.] E. H. B.

705. Black-body Radiation. G. W. Walker. (Roy. Soc., Proc. Ser. A. 89. pp. 398-398, Jan. 1, 1914).—The present paper was suggested by the discussion on radiation at the British Association Meeting of 1918. Planck's formula for the emission function E_λ is $c^2 h \lambda^{-5} / (e^{ch/\lambda T} - 1)$. This formula represents the observations for short and long waves at various temperatures with considerable closeness; and, if it is the correct expression, it is held by some to prove that the classical equations of dynamics and electrodynamics are at fault. The present author thinks the classical equations are not in much danger if properly applied, and has accordingly tried to trace the dynamical explanation of the experimental data. There must be many formulæ which will express the data as well as Planck's form. In the search for such, a clue soon appeared and led to the formula—

$$\phi(\lambda, \theta) = k\theta^5 \frac{\lambda^4 \theta^4}{[(\lambda^2 \theta^2 - a^2)^2 + b^2 \lambda^2 \theta^2]^2}$$

The function satisfies the following conditions. (1) It gives Stefan's law that the total radiation varies at θ^4 , since—

$$\int_0^\infty \frac{x^4 dx}{[(x^2 - a^2)^2 + b^2 x^2]^2} = \frac{\pi}{4b^3} \quad (a \neq 0 \text{ and } b +).$$

(2) It gives Wien's law that the maximum radiation at any temperature occurs when $\lambda_m \theta = \text{constant}$. In the formula here adopted $\lambda_m \theta = a$. (3) It gives the condition that the max. radiation at any temperature for this wave-length λ_m varies as θ^4 . In the author's formula $\phi_{\text{max.}} = k\theta^5/b^4$. (4) It gives Rayleigh's formula for long waves $\phi = k\theta/\lambda^4$. These conditions are required by the experimental work of Kurlbaum, Wien, Paschen, Lummer and Pringsheim, and Rubens. The remaining point was accordingly whether the formula will fit the result of (say) Lummer and Pringsheim for short wave-lengths. For this b^2 could be equated to $4a^2$, and then the simpler form becomes $\phi = k\theta^5 [\lambda\theta/(\lambda^2 \theta^2 + a^2)^4]$. It then follows from the data $\lambda_m \theta = a = 2940$, where the units are λ_m in microns (10^{-4} cm.), and θ in Centigrade degrees absolute. Taking the experimental curve of Lummer and Pringsheim at 1450° abs., for which λ_m is practically 2μ , the curve was calculated from the formula and fits the whole experimental curve excellently.

It is thus claimed that a formula has been found that fits all the data as well as, if not better than, Planck's. It is admittedly empirical, and may not stand alone. But in form it suggests what may be expected from a

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dynamical system with very heavy damping, and is shown to satisfy the electrodynamics of Larmor. More correct expressions for the vibratory motion than that of Lorentz and used by Planck are then put forward. These lead to equations which may be regarded as applicable to the behaviour of a molecule made up of a heavy, and so comparatively stationary, positive particle with a single electron revolving round it. The vibrations are of two types. In the first, which closely agrees with Lorentz's result, the damping is for optical purposes small, and the reduction of amplitude in the time between two collisions of a molecule with its neighbour would be small. But in the second type the frequency is enormous and the damping so great for optical purposes that the reduction of amplitude to a small fraction of its original value may be regarded as instantaneous. Just after each encounter the amplitudes of the two types may be regarded as comparable, but before the next encounter the second type will have been suppressed by almost instantaneous radiation, while the first type will not have suffered any great reduction. Is there not here a clue to the "quantum" theory and the characteristic Röntgen radiation? It is finally suspected that black-body radiation is determined not by the electron, nor by the positive particle alone, but by the joint action of the two. [See Abstract No. 520 (1912).]

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

706. *Kinetic Theories of Electronic Motion.* H. A. Lorentz. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 152-156, 1913.)—Gives a summary of electronic theories of metallic conduction. Shows that only one species of free electrons can exist, and that these are separated from the atoms by a kind of dissociation. If X is the field due to an external electric field and a molecular field within a conductor in the direction x , then the electric current per unit sectional area is $i = adT/dx + \beta(X - K)$, and the thermal current is $w = -\gamma dT/dx + \delta(X - K)$. The quantities $\alpha, \beta, \gamma, \delta$ and K , which have definite values at a given point, must be determined by a kinetic theory of electrons. They can then be used to express the thermal and electrical conductivities, the thermoelectric power, the Peltier and the Kelvin effects. K is the value of X required to produce a uniform temperature throughout. The author does not believe that J. J. Thomson's explanation of diamagnetism by means of electronic orbits curved in the magnetic field can be carried through, as the distribution function in the magnetic field has the same form as outside it.

E. E. F.

707. *Electrodynamics of Moving Ponderable Media and the Principle of Relativity.* H. R. Hassé. (Phil. Mag. 27. pp. 43-58, Jan., 1914.)—A mathematical and descriptive treatment of the equations of Lorentz, of Larmor, and of Minkowski. It is pointed out that Minkowski's equations are limited to the case of uniform translation though this is not always recognised. Towards the close of the article three interpretations of the symbols are discussed. The first leads to the equations of Minkowski, the second to those of Larmor or of Lorentz, while the third yield the equations of the field in the form adopted by G. T. Walker. But this last form does not completely satisfy the principle of relativity.

E. H. B.

708. *Classification of Electromagnetic Fields.* H. Bateman. (Phil. Mag. 27. pp. 186-147, Jan., 1914.)—Analytical.

E. H. B.

709. *Polarisation and Energy Loss in Dielectrics.* A. W. Ashton. (Phys. Soc., Proc. 26. pp. 43-58; Discussion, pp. 53-54, Dec., 1913.)—Discusses the relation between the coefficients in v. Schweidler's modification of Pella's equation for the electric displacement in a viscous dielectric [see Abstract No. 650 (1908)]. It is shown that where the polarisation current of a dielectric under a steady e.m.f. is proportional to t^{-n} , the viscous capacity of any group of molecules with the same time constant of displacement is proportional to the $(1 - n)$ th power of that time constant. It is hence shown that under an alternating e.m.f. of a frequency greater than about 1 per sec., the energy loss is proportional to the n th power of the frequency, and the viscous capacity proportional to the $(n - 1)$ th power. An expression is obtained for the variation of capacity with change of frequency in the special case when $n = 1$. The experimental results of various investigators are shown to be in fair agreement with these deductions from the modified theory, but it is proposed

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to carry out a series of tests of the constancy of n for a given dielectric at constant temperature but under varying frequencies. In conclusion, a brief *résumé* of Pellat's original theory is given. In the *discussion*, **A. Russell** said he thought Pellat's theory to be unsound and Schweidler's modification too artificial to be of practical value, while **W. H. Eccles** objected to it on the ground that an infinite number of exponential terms were required by it, accurately to represent the results of experiment. The **Author**, in reply, pointed out that a limit to the number of terms was fixed on the one side by the point at which the capacity ceases to be affected by an increase in frequency, and on the other by the time required fully to polarise the dielectric by a steady e.m.f.

J. W. T. W.

710. Electric Charge of Atmospheric Precipitations. G. C. Simpson. (Phys. Zeitschr. 14. pp. 1057-1066, Nov. 1, 1918.)—Deals with the theory of thunderstorms [Abstract No. 848 (1910)] and with certain objections based by Schindelhauer upon data obtained at Potsdam. Shows that the latter are consistent with the assumption that the disintegration of a rain-drop liberates a charge of 0.005 e.s. unit, and that there is no evidence that thunderstorms are due to an influence effect as illustrated by the influence machine.

E. E. F.

DISCHARGE AND OSCILLATIONS.

711. Flame Couples. G. Moreau. (Comptes Rendus, 157. pp. 1070-1072, Dec. 1, 1918.)—A continuation of previous work [see Abstract No. 517 (1914)]. The present paper deals with couples using two flames. Two Bunsen burners are placed together so that the flames are in contact: one is charged with a saline vapour. In each flame is placed a Pt electrode at about 1400° abs., bare, or covered with a deposit capable of emitting many corpuscles. The e.m.f. of such a flame-couple can be calculated from the formula $E = 0.178 \log (n_1/n_2)$ volts, which is applicable when the two electrodes are covered with an oxide of one of the alkaline earths and are at 2000° abs.; n_1 and n_2 are the concentrations of the ions in the two flames. Various salts were used and the measured values of the e.m.f.'s agree well with the values calculated from the above formula. The series: bare Pt—pure flame—salt flame—covered Pt, and bare Pt—salt flame—pure flame—bare Pt are also dealt with.

A. W.

712. Recombination of Ions made by α -Rays. H. Ogden. (Phil. Mag. 96. pp. 991-1001, Dec., 1918.)—It is known that the field required to obtain the full ionisation current in a gas in which a given number of ions are being produced each second is always very much greater if the ions are produced by α -rays than if they are produced by β -rays. Bragg and Kleeman attributed this difference to "Initial Recombination," and supposed that when ions are formed by α -rays the separation between the charges is less complete than when they are produced by β -rays, so that there is a marked tendency for the pair of ions to recombine before they can be separated by the field. Moulin, however, attributed the difference entirely to the difference in the initial distribution of the ions, in the case of α -rays the ions being produced in dense columns along the individual tracks of the α -particles, so that recombination proceeds more rapidly than in the case of the same number of ions distributed uniformly throughout the volume. The author, however, considers that the hypothesis of columnar ionisation does not seem capable of

explaining the whole matter, and in the present experiments the lack of saturation in ionisation by α -rays has been investigated for different gases. The Bragg "ionisation curve" apparatus was used and the current between two electrodes (one a wire gauze) 2 mm. apart was measured when α -particles traversed them normally, *i.e.* along the direction of the electric field. The current-potential curves were obtained, and compared with the relation deduced by Wheelock [Abstract 115 (1911)] on the basis of columnar ionisation. The results show that the latter theory does not apply, particularly in the cases of O, CO, and NH_3 , which theoretically should give nearly identical saturation curves, whereas experimentally NH_3 gives lack of saturation to by far the most marked degree. The suggested reason for the deviation from the exact law is the presence in the gases of a small percentage of ions of small mobility. This receives support from the fact that the nearer the temperature of a gas is to its boiling-point, the more does the gas exhibit initial recombination.

E. M.

713. Analysis of Canal Rays. J. Stark. (Phys. Zeitschr. 14. pp. 961-965, Oct. 15, 1918.)—Discusses the comparative merits of electromagnetic and spectroscopic analysis of positive rays. The spectroscopic method is better adapted to the discovery of positive rays of the higher valencies. This is due to the number of collisions of positive ions being necessarily greater in the spectroscopic method than in the electromagnetic method. These collisions, both in front of the cathode and behind it, give rise to ions of higher valency. In the case of heavy ions, like those of mercury, the advantage of numerous collisions for the formation of the higher valencies is evident even in the electromagnetic method. The latter method can be improved in this respect by making the pressure in front of the cathode as high as possible, preferably by the addition of a slightly dissipating gas like H or He. The capillary "canal" in the cathode must be made as narrow as possible so as to maintain the difference of pressure.

E. E. F.

714. "Field Canal Rays." J. Stark. (Ann. d. Physik, 48. 1. pp. 47-49, Dec. 81, 1918.)—Arguments showing that the remarks of Wagner and Kutschewski, to the effect that the observation of "field canal rays" escaped the notice of the author, are not borne out by the facts. [See Abstracts Nos. 1007 (1910), 128 (1914).]

A. E. G.

715. Theory of Ionisation by Collision. J. Franck and G. Hertz. (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 12-19, Jan. 15, 1914.)—A continuation of previous work [see Abstract No. 810 (1914)]. The discussion is based on Townsend's theory.

A. W.

716. Ionisation of Gases by Collision with Low Electric Forces. F. W. Wheatley. (Phil. Mag. 26. pp. 1084-1048, Dec., 1918.)—Townsend has shown that the process of ionisation by collision between the ions and molecules of a gas may be examined by investigating the currents between parallel plate electrodes when ultra-violet light falls on the negative electrode or when the gas is ionised by Röntgen or Becquerel rays. In the determinations which have already been made, the effect of the electrons for values of the ratio X/p larger than 60 has been obtained. The experiments described in this paper are undertaken with a view to finding the effects obtained by collision with smaller forces, and for that purpose it is necessary to measure the currents between plates at various distances apart to a high degree of

accuracy. A very constant source of radiation is therefore required for the experiments, and it would be practically impossible to obtain reliable results either with ultra-violet light or with Röntgen rays. The source of radiation used is polonium. The results show that the ionisation produced by α -rays is identical with that produced by Röntgen or Becquerel rays or by ultra-violet light, and has this advantage, that it produces a constant current. The apparatus is described in detail. The currents were measured by the zero method of Townsend with a condenser and a potentiometer. It is found that for values of X/p below 40 it was almost impossible to find the values of a/p when the pressure was as low as 9 mm. The value of a is so small that a very small error in observation would considerably affect the result. Also a 1% error in the e.m.f. would make an error of about 5% in a . With a higher pressure low values of X/p may very easily be found, and it is intended to extend the experiments by using large values of X and p in order to see for what range of pressures the formula $a/p = f(X/p)$ is satisfied accurately. For $X = 80$ to 270 the numbers at 0.4 cm., 0.8 cm., and 1.2 cm. show that the initial ionisation is uniform for these distances and almost proportional to the distance, and that the ionising power of the α -particle does not diminish.

W. R. Barss claims to have discovered a characteristic difference between the behaviour of gases and vapours at higher pressures. A series of experiments is made using SO_2 with the apparatus described in order to test the results obtained by Barss. There is no evidence from the results obtained to show that the behaviour of SO_2 at higher pressures is at all inconsistent with the theory of ionisation by collision as developed for gases. The experiments differ from those made by Barss in the manner in which the radio-active matter is distributed.

A. E. G.

717. *Failure of Photoelectric Effects with freshly-scraped Metal Surfaces when Gas capable of Reacting is excluded.* K. Fredenhagen. (Phys. Zeitschr. 15. pp. 65-68, Jan. 15, 1914.)—The theory is developed that photoelectric currents are produced on account of the presence of gases with which the metal can react. According to this theory, therefore, the current is due to the reaction between the metal, on which the light falls, and the surrounding gas; the immediate cause of the reaction being the light. H. Küstner. (Ibid. pp. 68-75, Jan. 15, 1914.)—Küstner attempts to prove the truth of the theory of photoelectric action as propounded by Fredenhagen. Full details of the experimental arrangements are given, together with the methods employed in making the measurements and the results of such measurements. These results, which have been obtained with zinc as the metal on which the light acts, show that when the surface of the metal is quite clean and all gas capable of reacting is excluded, there is no measurable photoelectric effect. It is certainly less than a thousandth part of that obtained under the usual conditions of experiment. The fatigue which occurs when gas capable of reacting is present, can be explained by reaction with adsorbed gases; the recovery, by diffusion of the reacting gas towards the zinc. Thus the velocity of reaction, and with it the strength of the photoelectric current, are regulated by the concentration of the reacting gas at the zinc. The pressure of neutral gas has no influence on the magnitude of the photoelectric effects so long as no ionisation by collision takes place.

A. E. G.

718. *Photoelectric Effect.* A. Hallermann. (Zeitschr. wiss. Phot. 18. pp. 186-207, Jan., 1914.)—Describes research on the influence of temperature and the occlusion of gases on the photoelectric effect of metals, metallic

oxides and sulphides. The results may be summarised as follows:—Temperature has no influence on the photoelectric effect of either metals or metallic oxides. No relation could be found between the Hallwachs- and the Wehnelt-effect. At high temperatures the electrodes show no fatigue. This supports the conclusion that the fatigue is in many cases dependent on the absorption of gases. The sparking potential, *i.e.* the potential at which the spark passes between the electrodes without illumination, is much reduced when the temperature is increased. Metals and metallic oxides show similar behaviour at high potentials. The shape of the curve showing the connection between the potential and the photoelectric current is identical at high temperatures with that at ordinary temperatures. At first the current increases proportionally with the potential; then follows "saturation," and finally the current increases very rapidly through ionisation by collision. The substitution of sulphide for oxide has no influence on the magnitude of the photoelectric effect, and here also temperature shows no change. If a metal under investigation is used as the anode for a glow discharge, its photoelectric sensibility is lessened; if used for the cathode the sensibility is increased. The higher the temperature, the smaller is this effect, and it quite disappears at about 400° C. A distinct influence of the chemical nature of the gases could not be decided. According to Skinner a metal used as cathode gives out gas, and used as anode absorbs gas; also at higher temperatures the absorption decreases. Hence the results now obtained support the observations of Millikan and Winchester and of Ladenburg, that the occlusion of gases diminishes the photoelectric sensibility.

A. W.

719. Long-wave Limits of the Normal Photoelectric Effect. R. Pohl and P. Pringsheim. (Phil. Mag. 26. pp. 1017–1024, Dec., 1918.)—It was with the purpose of discovering the relations existing between the photoelectric properties of the illuminated molecules and their other characteristic properties, in particular their chemical behaviour, that the investigations on the photoelectric effect have been extended to a rather large number of elements. That the characteristic frequency of the selective effect, despite uncertainties in the position of the resonance maximum, is a material constant related to the atomic radius has been pretty certainly established. But in the normal effect as well, a constant which is characteristic of the material seems to enter. From the experimental data at present known, it may be regarded as established that the long-wave limit of the normal photoelectric effect furnishes a measure of the binding force between the electrons and the illuminated molecule. On the other hand, any attempt to formulate this relation quantitatively is met with the difficulty that the values for the long-wave limits of the normal photoelectric effect in the case of many metals and alloys are subject to variations as great as an octave and more. This difficulty is all the more real in that as yet we are not in a position to determine what influences, on and in the extremely thin bounding surface of the metal in which the light absorption takes place, are the determining factors in this displacement.

A. E. G.

720. Dependence of the Photoelectric Effect of Metals on the Surrounding Gas. G. Paech. (Ann. d. Physik, 48. 1. pp. 185–164, Dec. 81, 1918. Extract of Dissertation, Dresden.)—The paper describes observations on the photoelectric effect of Pt in the gases, air, H, and CO₂—both damp and dry—these being made with a view to comparing them with the results of similar

experiments by Ullmann with Zn [Abstract No. 960 (1910)]. In order to get rid of effects due to absorbed gases the Pt plate is first heated in a vacuum electrically. The apparatus used for measuring the photoelectric effect is so constructed that the gas surrounding the plate can be changed very rapidly. In this way perfectly definite results are obtained. The relative effects of the gases are found to be analogous for the two metals, which seems to point to the fact that the surrounding gas exerts a definite primary influence on the photoelectric effect and that the effect of the metal itself is of secondary importance only. Experiments are also described in which the effects of the admixture of various vapours, viz. of methyl alcohol, acetone, chloroform, benzene, and of water are investigated. The effects of these are found to be in the order of their dielectric constants. Similar experiments on pure gases of relatively high dielectric constants give very large increases in the photoelectric effect, so that it seems that this effect is closely connected with the dielectric constant, a view already expressed by Hallwachs from theoretical considerations. J. J. H.

721. Lecture Experiment to Illustrate Ionisation by Collision and to Show Thermoluminescence. F. J. Harlow. (Phys. Soc., Proc. 28. pp. 55-60, Dec., 1918.)—A spherical discharge bulb is constructed with four leads passing into it carrying two small coils of Pt-wire coated with aluminium phosphate and lime respectively. These substances yield, when heated, abundant supplies of ions (positive from the phosphate, negative from the lime). The Pt-wires are placed near the surface of the glass and in the plane of the coil wound round the bulb for the purpose of producing the electrodeless discharge. The intensity of the discharge produced depends on both gas pressure and induced e.m.f. For any given e.m.f. the discharge can be excited over a given range of pressure only, and, within this range, its intensity increases to a maximum as the pressure diminishes, after which it decreases slightly, then becomes visibly intermittent and finally disappears altogether. By heating up either the lime or the phosphate to incandescence two noticeable effects are observed. First the intensity of the discharge, provided this is not too great initially, is considerably increased, and, secondly, the lower limit of the pressure-range over which the discharge can be produced is considerably extended. The first of these shows the increased ionisation in the gas caused by the collision of ions from the incandescent solid with the molecules of the gas. The second effect is an illustration of the fact that the sparking potential is considerably reduced by the presence of initial ionisation, since the discharge being intermittent is practically a succession of sparks. An interesting point demonstrated by the experiment is the well-known spreading of the discharge, as the pressure is diminished, on account of the increased diffusion of the ions at lower pressures. It is also found that the lime used possessed the property of displaying thermoluminescence. In an appended note it is stated that this phenomenon is due to the combination of the lime and Pt, and the conclusion is arrived at that thermoluminescence may be closely connected with the electrical activity of salts and oxides upon metals.

Further experiments are in progress.

A. E. G.

722. Dependence of the Photo-electricity of the Metal on the Gas, in Particular the Cause of the Strong Photo-electricity of Potassium. G. Wiedemann and W. Hallwachs. (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 107-120, Jan. 80, 1914.)—An historical survey of the previous work upon the subject is first
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given. For the present experiments the apparatus used is similar to that previously described. A special arrangement, a diagram of which is given, is used for successive distillation of the potassium. The results show that the great photoelectric activity of potassium can be explained by the exceptionally large absorption of gas by that body, the presence of the gas being a necessary condition of the remarkable photoelectric activity. The theoretical aspect of the question is also discussed. A. E. G.

723. Conduction of Electricity in Extreme Vacuum. II. J. E. Lilienfeld. (Ann. d. Physik, 48. 1. pp. 24-46, Dec. 31, 1913.)—The subject is dealt with along the following lines:—Experimental expedients and the recovery of the vacuum. Comparison between series of experiments obtained at different times, 1909 to 1913. Experiments with fluid and solid hydrogen. Experiments with the high-vacuum valve. Comparison of results obtained with kathode of tantalum wire and with oxide-kathode. A general consideration of the results obtained. [See also Abstract No. 1818 (1910).] A. E. G.

724. Behaviour of the Wehnelt Electrode in Different Gases. K. Fredenhagen. (Phys. Zeitschr. 15. pp. 19-27, Jan. 1, 1914.)—It is found that nitrogen lowers the efficiency whilst the dependence on temperature continues constant. Oxygen also lowers the efficiency very much, and diminishes the dependence on temperature, especially at higher pressures. Hydrogen increases the effect and suppresses the temperature-influences almost completely. It appears, according to the results obtained with nitrogen, that the neutral gases lower the effect. An explanation of the results obtained with oxygen is offered. The failure of the temperature influences with hydrogen is difficult to explain and further research in this direction is necessary. Methane and coal-gas behave in a similar manner to hydrogen, while cyanogen acts like oxygen. A. E. G.

725. Effect of Space Charge and Residual Gases on Thermionic Currents in High Vacuum. I. Langmuir. (Phys. Rev. 2. Ser. 2. pp. 450-486, Dec., 1913.)—In this paper the author shows both theoretically and experimentally that the space charge in a space devoid of positive ions limits the current that flows from a hot kathode to a cold anode. Expressions are obtained giving the max. current possible for a given p.d. between parallel plate electrodes or between concentric cylinders. The experimental curves in which current is plotted against temperature follows Richardson's equation, viz. $i = a\sqrt{T}e^{-b/T}$, at the lower temperatures, but at the higher temperatures the current becomes independent of the temperature, reaching a kind of temperature saturation value; this value is dependent upon the voltage, being proportional to $V^{3/2}$. In the presence of gas, at pressures above 0.001 mm., and at voltages above 40 volts, there is usually sufficient production of positive ions to reduce greatly the space charge and thus to allow more current to flow than is indicated by the formulæ. At very low pressures the effect of most gases is, contrary to ordinary opinion, to reduce the electron emission from an incandescent metal, the effect being specially marked at low temperatures. The constant b of Richardson's equation is always increased, in the case of tungsten, by the introduction of O, N, CO, CO₂, or water-vapour. Argon, however, has no effect on either a or b , the values being the same as those in a perfect vacuum, viz. $a = 84 \times 10^6$ amps. per sq. cm. and $b = 55,500$. The presence of ionisation in the argon greatly reduces the space charge and large currents can be

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obtained with relatively small voltages. The effect of N in decreasing the thermionic current from tungsten depends on the voltage of the anode, the current with 240 volts being in many cases less than with 120 volts. With oxygen, the effect is independent of the anode voltage. The following theory seems to account for most of the observed phenomena and is apparently not inconsistent with any. The effect of gases in changing the saturation current is due to the formation of unstable compounds on the surface of the wire. In the cases observed the presence of the compound decreases the electron emission although in some cases it might cause an increase. The extent to which the surface is covered by the compound depends on the rate of formation of the compound and on the rate of its removal from the surface. The compound may be formed on the surface directly by the reaction with the gas as in oxygen, or by reacting with positive ions which strike the surface as with nitrogen. The compound may be removed from the surface by decomposition, evaporation, or cathodic sputtering (*i.e.* being driven off by the bombardment of positive ions). The results obtained by other observers are discussed, and it is pointed out that failure to observe the requisite conditions is probably the cause of their having found that the thermionic currents tend to decrease with increasing purity of the kathode and progressive improvement of the vacuum. As the result of his investigations the author concludes that the emission of electrons from an incandescent solid in a very high vacuum, *i.e.* below 10^{-6} mm., is an important specific property of the substance and is not due to secondary causes as has been recently supposed.

F. J. H.

726. Quantum Hypothesis and Electric Discharge from Hot Bodies. W. Wilson. (Ann. d. Physik, 42. 6. pp. 1154–1162, Dec. 23, 1918.)—A theory of the electric discharge from hot bodies is here discussed, its basis being the quantum hypothesis of Planck. The formula thus derived accords with experimental results at least as well as the hitherto-used formula of Richardson. The theory brings the phenomenon of the electric discharge of hot bodies into relation with other phenomena, *e.g.* the discharges through the incidence of Röntgen rays and of ultra-violet light, whereas these have usually been regarded as essentially different from the discharge from hot bodies. [See Abstracts Nos. 1874 (1912) and 1985 (1918).]

E. H. B.

727. Law for Conduction through Gases in Cylindrical Fields. V. Schaffers. (Comptes Rendus, 157. pp. 1417–1419, Dec. 22, 1918.)—The paper deals briefly with two empirical formulæ advanced by the author which give the connection between the current density and potential in a gas contained between concentric cylindrical electrodes, the inner of which is covered with an ionised layer. The formulæ, the applicability and limitations of which are discussed, are considered to be more satisfactory than that deduced by J. J. Thomson.

F. J. H.

728. Heating Effects at the Anode in Vacuum-tubes. B. Hodgson. (Phil. Mag. 27. pp. 189–202, Jan., 1914.)—In a previous communication the author showed that the energy communicated to the anode during discharge in air was approximately proportional to the current through the tube. The experiments were made with gas pressures 2.7, 1.05, and 0.68 mm. The experiments here described have been carried out over a large range of currents and pressures in oxygen. The apparatus used was that previously

described [see Abstracts Nos. 1187 (1918) and 141 (1914)] ; the method of experimenting is slightly altered. Instead of allowing the anode to rise to that temperature at which the loss of energy by radiation is equal to the gain from the bombardment of negative carriers, the rise in temperature in a definite interval of time is measured, and a correction for loss by radiation applied. This method is found to yield results much more quickly with only a small loss in accuracy. The anode used is of lead, and has a heat capacity of 2.2 gm.-cals. When energy supplied to the anode per sec. is plotted against current for constant pressure, a linear relation exists at the pressures used. For lower pressures the curves are of a different type. For small currents proportionality exists between current and energy, and then, as the current increases, the energy communicated to the anode actually decreases and falls to a minimum value, after which a quick rise is obtained. If the mean potential through which an ion falls be plotted against pressure with constant current the curves all show a pressure-range from 2 to 4 mm. in which the energy given to the anode is approximately constant. As the pressure is reduced the energy per ion increases to a maximum at about 1.5 mm. pressure. It then falls to a minimum whose position and value vary with the current, and after this minimum a rapid rise is obtained for lower pressures. Neglecting distortions with short distances the energy given up to the cathode is independent of the length of the distance between the electrodes. This agrees with the assumption that the bulk of the positive ions originate in the negative glow. Were any produced in the space nearer the anode, the energy given up would increase with the distance between the electrodes. In the case of the anode an increase in the distance between the electrodes is accompanied by an increase in energy. Though the curves obtained showed a tendency to reach a maximum, none was reached even with a length of discharge of 24 cm.

The mechanism of discharge is discussed in the light of these results.

A. E. G.

729. Short Spark-gaps between Metals. E. Taege. (Phys. Zeitschr. 14. pp. 1041-1042, Nov. 1, 1918.)—Studies the influence of metal and gas on the quenching of sparks in a gap common to two closely coupled but non-syntonic circuits. The quenching is greatly increased by shortening the spark-gap. It is greatest in the gases of highest thermal conductivity and ionic mobility, the series of increasing action being Cl, Ni, air, O, NH₃, CH₄, coal gas, H. Chemical action between gas and metal is of no account, but those metals show the greatest quenching action which have the lowest electronic emission. Ca and Mg quench feebly; Al, Ni, and Zn a good deal better; and Ag, Pt, Cu, and brass best. Analysis of the sparks by Feddersen's mirror showed an afterglow in the case of Ca, Mg, Zn, and Sn, and stray discharges in the case of Mg and Ca. The thermal conductivity of the metal has no influence on the quenching.

E. E. F.

730. Explosive Luminous Phenomenon in Rarefied Nitrogen. J. de Kowalski. (Comptes Rendus, 158. pp. 625-627, March 2, 1914.)—According to Strutt, active nitrogen is formed by high-frequency discharges in the rarefied gas, especially when the latter is free from oxygen. Neither Comte nor Tiede, however, was able to obtain the active gas unless traces of oxygen were present. The results of the author's experiments confirm Strutt's assertion and bring to light a phenomenon not previously described. The purified nitrogen being enclosed in a flask with two stout copper ribbon spirals passing round the middle, the production in the spirals of very

powerful high-frequency currents is accompanied by an annular luminous phenomenon determined by the induced field. When the pressure under which the nitrogen is subjected to the oscillating discharge is less than 5×10^{-4} mm., the appearance observed depends on the intensity of the induced electric field: (1) A relatively feeble field gives an annular discharge, the spectrum of which is composed of that of nitrogen together with a very faint mercury line, $\lambda = 546$; the latter is scarcely perceptible when cooling in liquid air is resorted to. (2) A very intense electric field gives a number of concentric rings of different colours, with which correspond distinct spectra. The Hg spectrum appears very sharp and is but slightly weakened by liquid air; this contamination of the gas by the mercury of the pump is, as was pointed out by Wachsmuth, very persistent. If, in case (1), the current is interrupted, the gas exhibits an orange phosphorescence for some minutes, as was described by Trowbridge and by Strutt; its spectrum corresponds with that of Strutt's active nitrogen. But interruption of the strong current is immediately followed by slight luminous explosions in the gas. The latter becomes far more highly illuminated in this phase than in the subsequent phosphorescence of the nitrogen, its colour being an intense bluish-violet. In 1898 Threlfall found that, under the action of discharges between a mercury and another electrode, an explosive nitride is formed in nitrogen, while the same nitride is formed under the action of Strutt's active nitrogen. The above phenomenon is doubtless also due to the formation of this nitride. As little as 10^{-9} mgm. of Hg is required to show the lines of this metal in the spectrum of the luminous phenomenon resulting from these explosions. T. H. P.

731. Reflection of Electromagnetic Waves by Gratings. W. Arkadief. (Russian Physico-Chemical Soc., Journ. 45. pp. 45-60 [Physical Part], 1918.)—The author has investigated the energy, y , reflected at gratings composed of four thin wires. Experiment shows that for non-magnetic wires the value of $A = y_0 - y$ (where y_0 is the energy reflected for zero wire resistance), increases somewhat more slowly than the square root of its resistance, while A increases with the wave-length. Measurements on the influence of the material of which the wire is composed were also carried out by the method which makes use of a single inclined wire stretched between two crossed Hertz mirrors. It was found that in both cases there is a similar dependence of the value of A upon the resistance of the wire. Both methods show further, that the values A_1 for magnetic wires are greater than for non-magnetic ones of equal resistance. The quotients $q = A_1/A$ for iron, steel, nickel, and krupp in for different wave-lengths are given in a Table in the original; q appears, independently of the method used, to decrease at the shorter wave-lengths and seems to approach unity at wave-length 1 cm. This result of the disappearance of the magnetic quality with the shortest waves has already been referred to by the author in his paper on the absorption of electric waves at two parallel wires [Abstract No. 1732 (1918)]. L. H. W.

732. Phenomena in Oscillation Circuits. I. F. F. Martens. (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 100-106, Jan. 80, 1914.)—This first part of the treatment of two circuits in which electric oscillations are occurring is confined to the rigorous calculation of the instantaneous alternating charges and currents under given coupling (magnetic or electric). [See Abstract No. 668 (1918).] E. H. B.

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733. *Disturbing Influence of Walls of Room on Measurements of Wave-length and Decrement of Short Electric Waves.* M. Sjöström. (Ann. d. Physik, 42. 6. pp. 1531-1560, Dec. 23, 1913.)—The paper shows how the reflection of the waves from the walls of the room in which measurements are made deforms the resonance curves and thus gives rise to wrong values of wave-length and decrement. The floor and ceiling of the room are the chief cause of the disturbance when the oscillator and resonator are parallel to them, and exercise an effect even when the oscillator and resonator are near each other and at some considerable distance above the floor. If the resonator is kept a constant height from the floor, and moved away from the oscillator, the intensity curve obtained shows periodic variations. The position of these variations agrees with that calculated from theory on the assumption that they are due to reflection. Throughout the experiments an oscillator of a new type is used. The sparks are very short and pass between flat silver plates between which a current of hydrogen saturated with alcohol vapour is passing. The radiated energy is great and constant in quantity. Mixtures of gases passing between the electrodes give much better effects than do the constituent gases of the mixture, when used pure. T. P. B.

734. *Effect of Ionisation of Air on Electrical Oscillations and its bearing on Long-distance Wireless Telegraphy.* G. W. O. Howe. (Phil. Mag. 27. pp. 218-215, Jan., 1914.)—This paper is a comment on the results obtained by Barton and Kilby [see Abstract No. 829 (1914)] on the effects of ionisation of air on electrical oscillations. The paper referred to cannot be taken to support Eccles' theory of the refraction of electromagnetic waves, since that theory requires that the ion be free from frictional resistance, whilst the experiments were carried out at atmospheric pressure. It is suggested that experiments in various vacua would have a better bearing on the theory. E. H. Barton. (Ibid. pp. 381-382, Feb., 1914.) T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

735. *Behaviour of Crystalline Selenium towards Luminous Radiations.* P. Pignataro. (N. Cimento, 6. Ser. 6. pp. 826-834, Nov., 1913.)—In order to study the action of a constant illumination on the resistance of selenium, which shows its max. variation in a fraction of a second, the author has utilised the deviation produced in the kathode rays in a Braun tube by the action of a magnetic field caused by the current traversing a selenium preparation. The results show that an infinite number of resistance curves may be obtained, since with any particular intensity of light there corresponds no single resistance. But leaving aside the alteration which may be produced in the sensitiveness of the cell by a very intense light, these curves should not surpass a certain limiting position depending on the maximum and minimum values of the light intensity. The max. variation of resistance for a sudden illumination is produced in about $\frac{1}{4}$ sec.; in the succeeding period of 4 or 5 secs. the variation continues in the same direction but with diminished rapidity, the definite minimal resistance being attained only after several hours. The reversion of the preparation to its normal state after the suppression of the illumination proceeds similarly but occupies a greater period of time than is required for the attainment of the max. conductivity. Hence the laws according to which the resistance of Se decreases under the VOL. XVII.—A.—1914.

influence of light and subsequently increases in the dark are not exactly the inverse one of the other. The times required for the conductivity to reach its max. value in the light and then its original value, increase with the intensity of the exciting light. T. H. P.

736. Influence of Various Metals on the Thermoelectric Properties of Iron-Carbon Alloys. E. L. Dupuy and A. Portevin. (Comptes Rendus, 157. pp. 776-779, Nov. 8, 1918.)—The number of alloys dealt with was sixty—(Fe, C 7; Fe, C, Cr 17; Fe, C, Mn 4; Fe, C, Al 7; Fe, C, Si 7; Fe, C, W 10; Fe, C, Mo 8)—and they were tested in two conditions: (1) After annealing 8 hours at 900-1000°, the cooling having lasted about 8 hours; (2) after tempering from 1000° in water at 14°; the initial temperature having been chosen high to cause solution of the carbides. The curves showing the change in the thermoelectric power indicate that in general this is diminished by tempering. The curves may be divided into two groups: (I) The metals, Mn, Si, Al, give a continuous curve resembling the first branch of the letter U. This resembles the behaviour of irreversible nickel-steels. The behaviour shown indicates the formation of solid solutions. (II) In metals such as Cr, W, Mo, there is first a rapid fall in the curve (indicating formation of a solid solution) and then a rise which seems to correspond to the saturation of the solution. The curves have the form of an horizontal S. The three metals are amongst those which, when added to an iron-carbon alloy rich in carbon give rise to carbides. Thus an idea may be attained of the limit of solubility in the solid state of the metals in the alloys of Fe and C. The carbides become isolated when saturation is attained, perhaps as a constituent of pearlite, perhaps as an extra-eutectic constituent. J. J. S.

737. Bismuth Thermopiles. W. W. Coblenz. (Frank. Inst., Journ. 176. pp. 671-676, Dec., 1918.)—This note describes experimental tests which contradict some theoretical views relative to the construction of thermopiles. It is not the case that the external resistance and the internal resistance of the thermopile should be equal for max. efficiency. The external resistance may be several times that of the internal without seriously affecting the efficiency. Some of Johansen's rules as to radiation sensitivity are only approximately true. The novelty of the Bi-Ag thermopile is the completely opaque receiver, while the symmetry of the hot and cold junctions is maintained. With various thermopiles it was found that one microwatt produces a rise in temperature of about $15^{\circ} \times 10^{-6}$ C. above the surrounding air. This appears to be the most logical way to rate the efficiency of a thermopile. The most promising thermopile seems to be one having elements of pure Bi and an alloy of Bi + 6 % Sn, joined in series-parallel. J. J. S.

738. Thermoelectric Forces of Bad Conductors. A. Weissenberger. (Phys. Zeitschr. 15. pp. 105-107, Jan. 15, 1914.)—Determines the Peltier-effect in a Nernst filament against Pt, which was found by Shearer [Abstract No. 1102 (1912)] to be very high. The thermo-e.m.f. is negative (as of Fe against Cu) and amounts to 580 microvolts per degree at 1000° in case of a fresh filament, and about double that amount in the case of a burnt filament. Quartz glass shows a very similar behaviour, and in both substances there is no trace of polarisation. Soda glass, on the other hand, shows a positive e.m.f. accompanied by well-marked polarisation, probably due to ionisation of the glass. E. E. F.

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739. Polarisation of the Volta-effect by Gaseous Discharges. **E. Wertheimer.** (Deutsch. Phys. Gesell., Verh. 15. 24. pp. 1888-1847, Dec. 80, 1918.)—Experiments are described in which the Volta-effect for each of the metals Pt, Au, Ag, Cu, Fe, Ni, Pb, Cd, and Zn is measured as soon as possible after its use as the kathode for discharges of short duration in air and oxygen. The discharge in both cases is found to produce a polarisation of the effect, the metals becoming more electro-negative; a subsequent discharge in hydrogen, however, or the immersion of the metal in steam for a few seconds invariably diminishes the effect considerably. If the metal is left to itself the polarisation diminishes gradually, the original Volta-effect being regained in a few hours with some metals, with others in a few days. The p.d. between two plates of Cd, one of which had been subjected to the discharge in oxygen was found to be as much as 1.75 volts. The values obtained for the polarisation voltage generally do not show constancy for the same gas; they seem to depend upon the previous treatment of the metal and upon the conditions of the discharge which are not always reproducible. F. J. H.

740. Influence of Diffusion on Conductivity of Ionised Gas in Plane Condenser. **G. Jaffé.** (Ann. d. Physik, 48. 2. pp. 249-281, Jan. 28, 1914.)—A mathematical paper in which certain formulæ are derived, but no experimental data are yet extant for comparison with them. E. H. B.

741. Induction of Two Circular Currents. **E. Mathy.** (Journ. de Physique, 8. Ser. 4. pp. 970-974, Dec., 1918.)—In a former paper a formula was established for the evaluation of the coefficient of induction of two circular circuits. The author now gives a general solution of the system. C. P. B.

742. Wheatstone Bridge with High-frequency Current. **W. Hertwig.** (Ann. d. Physik, 42. 6. pp. 1099-1108, Dec. 28, 1918.)—The author continues Nernst's work on the application of high-frequency current in the Wheatstone bridge to the determination of dielectric constants [see Physical Soc. Abstracts Nos. 81 (1896), 408 (1897), and Science Abstracts No. 1517 (1904)]. The bridge forms part of a secondary circuit excited by the quenched-spark method; it consists of four similar condensers, the two on each side having a common plate. In this way the self-induction of one pair of connecting wires is cut out. The other connecting wires are cut very short. The frequency employed is 10^6 per sec. A PbO_2 -graphite combination is used as detector. The liquid of which the dielectric constant is required is placed in a specially-constructed vessel, which is connected in parallel with one of the condensers. The change in the capacity is balanced by inserting a glass plate between the plates of the corresponding condenser. If the liquid shows conductivity, resistance is inserted in parallel with the corresponding capacity. The special variable resistance employed is a thread of electrolyte in a capillary tube. Thus error due to change in self-induction or capacity by insertion of the resistance is avoided. T. P. B.

743. Electrical Resistance of Mixtures of Xylol and Alcohol. **N. Campbell.** (Phil. Mag. 26. pp. 1044-1058, Dec., 1918.)—Some further experiments have been made on the high resistances of mixtures of xylol and ethyl alcohol in glass tubes, to which reference has been made in previous papers [Abstracts Nos. 678 (1910) and 1104 (1912)]. The investigation was undertaken mainly with the object of obtaining information bearing on their use in
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practice, but at the outset a point of theoretical interest was determined. It is to be expected that the mechanism of conduction in such a mixture should be similar to that in an electrolyte, but the previous experiments had shown that the conductivity of the mixtures differed from that of electrolytes in two particulars. First, the conductivity decreased with the temperature, like that of a metal; secondly, it appeared to be unaccompanied by polarisation. However, a little consideration shows that the second and most remarkable feature does not indicate that the conduction is not electrolytic. It appears that the easiest way to prepare a known resistance is to make the mixture out of commercial alcohol and xylol and then to measure its resistance and temperature coefficient. If a resistance of a definite number of ohms is required, the conductivity constant of the cell can be estimated from its dimensions: it can then be filled with a mixture of such conductivity that the cell will have the desired resistance. In this way a cell can easily be prepared with a resistance which does not differ from that desired by a factor of 8. If a closer adjustment is required, another mixture having the desired conductivity can be prepared from the same alcohol from the information contained in a given table. If a resistance of about 10^6 ohms is constructed and an accurate voltmeter is available, such a resistance can be compared with an accuracy of 0.5 %, with any resistance between 10^6 and 10^{10} ohms by means of the method shown. When it is desired to measure very small currents there seems to be no advantage in choosing a resistance of more than 8×10^{11} ohms; with such a resistance a change in the current of 8×10^{-16} amp. can be certainly detected. If a higher resistance be taken the conductivity of the insulation of the apparatus is apt to be comparable with that of the resistance, and if, as is usually the case, the currents measured are those due to radio-active rays, v. Schweidler's fluctuations prevent any increase in the accuracy of the measurement. These high resistances appear to provide the most convenient means of determining small currents of 10^{-10} amp. or less in absolute measure. They are both cheaper and easier to use than either standard capacities or quartz piezoelectrics. A. E. G.

744. Silver Voltmeter. E. B. Rosa, G. W. Vinal, and A. S. McDaniel. (Electrical World, 68. pp. 873-874, Feb. 14, 1914.) [See Abstracts Nos. 501, 675 (1918).]—The object of the present work was to make a further comparison of the porous cup and Smith forms of voltmeter, the results being expressed as the voltage of the Weston normal cell at 20° C. computed from the defined electrochemical equivalent of silver, 1.11800 mgm. per coulomb. The result of 156 deposits in the porous cup form is 1.01826; int. volts, and the result of 55 deposits in the Smith form is 1.01827, int. volts. The average deviation of a single observation from the mean is from 8 to 4 parts in 100,000. With other forms of voltmeter the following results have been obtained: Siphon form, 1.01882; modified siphon form, 1.01885; Poggendorff form, 1.01880. It was learned from previous work that the effect of acid in pure electrolyte is to lower the mass of the deposit, and the authors give a quantitative relation between the amount of acid expressed in equivalents of HNO₃ per million (X), and the decrease in deposit also expressed in parts per million (Y). The relation is $Y = -4.5X + 0.02X^2$. A number of miscellaneous observations were made on the effect of various impurities, but mention need only be made here of the excessive deposits obtained when considerable CO₂ is present in the atmosphere above the voltmeters. The authors think that both silk and filter-paper should be excluded from use in the voltmeter. F. E. S.

745. *Weston Normal Cell.* J. Pougnet, E. Segol, and J. Segol. (*Comptes Rendus*, 157. pp. 1522-1525, Dec. 29, 1918.)—The authors find ultra-violet light to affect the e.m.f. of a standard cell. As glass is opaque to the ultra-violet rays the cell was set up in a vessel of quartz. It was placed 12 cm. from a 440-watt Cooper-Hewitt lamp and in 80 mins. 10 secs. its e.m.f. diminished from 1.0252 volts to 1.0192 volts. The temperature of the cell increased in the interval from 26° to 40° C., and when allowance is made for this the fall in e.m.f. due to the action of the ultra-violet light is calculated to be 0.0066 volt. The lamp was removed after the exposure of 80 mins. 10 secs. and the cell gradually increased in e.m.f. until at the expiration of 89 mins. (69 mins. 10 secs. from the commencement of the exposure) its e.m.f. was quite normal. The authors propose to continue the study. F. E. S.

746. *Reflecting Electrodynamometer.* A. Palm. (*Zeitschr. Instrumentenk.* 88. pp. 868-878, Dec., 1918.)—A description of a reflecting electro-dynamometer of high sensibility in Hartmann and Braun's laboratory. The instrument has the moving coil and 2 fixed coils in sections, which can be used separately if desired. The moving coil has 7 turns, is of 18 ohms resistance, and has a self-induction of 4 microhenries. The fixed coils have 800 turns, are of 800 ohms resistance, and have a self-induction of 2 henries. The instrument is used (1) for indicating and measuring very small currents and voltages and their components, using an auxiliary current of adjustable phase in the fixed coils. (2) As a wattmeter for small power measurements. The voltage is across the fixed coils and the moving coil carries the current. (8) For measuring currents or voltages, the fixed and moving coils being in series. The moving coil is controlled by a Pt-Ni strip 7 cm. long, and the current enters and leaves by gold wires specially arranged. To compensate for the self-induction of the moving coil, a coil of a similar number of turns is arranged as nearly as possible coincident with the moving coil. F. E. S.

747. *A Rapid Thermopile.* W. J. H. Moll. (*Konink. Akad. Wetensch. Amsterdam, Proc.* 16. pp. 568-571, Dec. 27, 1918.)—A description is given of a thermopile designed to give rapid indications. In its construction a prompt heat-exchange and a wide surface exposed to radiation are secured, and thus a high degree of both rapidity and sensitiveness has been attained. The thermopile is built up of a great number of metal strips. Each of these consists partly of constantan and partly of copper, and is soldered at both ends to two copper bars. This constantan-copper strip can be exposed to radiation throughout its entire length. Then on account of the great difference in heat capacity of the two junctions one will attain a higher temperature than the other: the equilibrium of temperature is attained in a very short time owing chiefly to the good heat-conduction between the junctions. As Cu and constantan differ considerably in heat-conductivity the two metals which form the strip are taken of different thickness and length. Such elements can readily be combined to form a pile. In one such pile the total resistance was 9 ohms, and the radiation from a standard candle at a distance of 1 m. produced an e.m.f. of 18 microvolts, the current reaching 99 % of its definitive value within $1\frac{1}{4}$ secs. J. J. S.

748. *Sensitive Thermopiles.* E. S. Johansen. (*Phys. Zeitschr.* 14. pp. 998-1000, Oct. 15, 1918.)—Gives further details of the author's type of vacuum thermopile, which was criticised by Coblenz [*Abstract No.* 1600 (1918)].

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There are two constructions, one of which makes the "cold" junctions in the shape of solid copper blocks, while the other makes them as thin as the "hot" junctions. The latter form, originally devised by Rubens, has as constant a zero as the former, but the first type is $\sqrt{2}$ times as sensitive as the second.

E. E. F.

749. New Electrostatic Generator for High-tension Direct Current. H. Wommelsdorf. (Elektrotechn. Zeitschr. 85, pp. 61-64, Jan. 15, 1914.)—The characteristic feature of the *Kondensatormaschine* lies in the condenser-like interleaving of the rotating and stationary discs and static fields; in operation the machine resembles a self-charging and discharging condenser. The rotating disc of an influence machine is subject to influence on one side only; electricity is drawn from the other side. In the present machine the rotating discs are influenced on both sides, and the charge is collected by steel wires dipping in grooves round the rims of the discs. At least twice the output of a corresponding influence machine is therefore obtained, but actually a condenser machine yields from 20 to 50 times as much electricity as a multiple-plate influence machine of the Holtz-Wimshurst double rotation type, owing to the very much smaller gap between the plates of the former. Owing to their dependence on atmospheric conditions, Wimshurst machines are ill-adapted to practical work. The author's 1907 machine—the forerunner of the present type—has been used extensively, and is characterised by the embedding of the sectors in vulcanised insulating material. This construction increases the current- and pressure-output, and improves the self-excitation of the machine besides increasing the life of the plates. In the condenser machine the sectors and the static field systems are similarly embedded. A completely enclosed and strongly built two-piece stationary shell contains the static field systems, between which rotate the influence discs; all the active parts are protected from dust and radiation losses. The rotary polariser is a simple rod so arranged that it can be used simultaneously to short-circuit the electrodes and the static fields. Two regulating series gaps are provided as well as a switch controlling the connection of the Leyden jars. An auxiliary gap on the baseboard serves for the withdrawal of high-frequency oscillating condenser-discharge current. The author points out the constructional weaknesses which limited the output and impaired the practical convenience of his earlier machines. To retain the advantages of vulcanite in other respects while avoiding its deterioration by ozone produced in and near the machine, the discs are made of vulcanite covered with a bakelite enamel (insoluble, hard, and highly polished). Either of two alternative connecting systems may be employed; these differ from the old Holtz connections, a variable high resistance being placed between two sectors formerly under the influence of a short-circuiting polariser. This resistance may be provided most simply by varying the distance between the polariser brushes and the ball collector. With Leyden jars disconnected, the discharge takes the form of innumerable ramifications forming a noisy arc over short gaps and retaining the form of a continuous flame discharge up to a gap of 220 mm. (modern 5-plate machine). Individual sparks can only be recognised when longer gaps are used. With the jars connected, a brighter and more crackly discharge is obtained without sacrificing spark-length. The polariser makes possible accurate starting and stopping of the effective current at any desired moment, and, if necessary, reversal of polarity. The chief applications of the new machine are to electrotherapy and Röntgen-ray work; the wide range of current, pressure, and output is an important advantage.

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Rectified current is supplied, and the machine can be driven by hand if necessary. A Holtz-Wimshurst machine with two 55-mm. rotating discs provides up to 220 mm. spark-length and 70 milliamps. ; a condenser machine with five rotating 55-mm. discs yields 850 mm. spark and 2500 milliamps. (8500 milliamps. with 7 discs). These data assume practical values for the polariser angle ($> 80^\circ$) and speeds, etc. A condenser machine with one 26-mm. rotating disc provides about the same spark-length (175 mm.) as a Holtz-Wimshurst machine with eight 41-mm. rotating discs, and yields 850 milliamps. as compared with 110 milliamps. [See Abstracts Nos. 174, 798, 1027, and 1059 (1905).]

R. E. N.

750. Universal Magnetic Theodolite. N. Ogloblinsky. (Terrestrial Magnetism, 18. pp. 185-192, Dec., 1918.)—In 1909 designs were prepared for a new magnetic theodolite involving the principles utilised in the Russian Imperial Navy, but adapted for land observations. The new instrument was tested at the Constantin Observatory at Pavlovsk in 1911, and in the course of a magnetic survey along the shores of the Bay of Finland, near Cronstadt, in 1912, it gave satisfactory results under difficult conditions. The chief feature is the employment of two deflectors, one on each side of the suspended needle system, the advantage of which arrangement had been pointed out by Kelvin, and first employed by Gray in the Glasgow Physical Laboratory in 1885. This seeming complication affords the following advantages :—It permits the use of shorter magnets and makes the series for H/M and Z/M more convergent ; it abolishes the necessity of transporting the magnet from one side of the needle system to the other, and makes the measurements nearly independent of changes in the positions of the deflected needles within certain limits. Instructions are given for horizontal and vertical intensity determinations with the instrument.

C. P. B.

ALTERNATING CURRENTS AND MAGNETISM.

751. Wiedemann Phenomenon in Nickel Wires. T. Gnesotto and V. Mattioli. (N. Cimento, 6. Ser. 6. pp. 848-874, Nov., 1918.)—The experimental arrangements used by the authors were similar to those previously described [see Abstract No. 987 (1912)]. The paper comprises : (1) The study of a group of torsion cycles obtained with a nickel wire subjected to constant tension, the circular field—the current traversing the wire—being kept constant and the longitudinal field varied cyclically. (2) The description of a group of torsion cycles obtained with the same wire at the same tension as before, the value of its longitudinal field being maintained constant while the circular field is varied cyclically. (8) The description of further groups of cycles obtained with the same nickel wire as above but subjected to a different tension, and with other nickel wires of different diams. and subjected to suitable tensions, first one and then the other of the two fields being varied. Detailed results and the corresponding curves are given in the original.

T. H. P.

752. Intense Magnetic Field with Comparatively Small Electromagnet. H. Deslandres and A. Perot. (Comptes Rendus, 158. pp. 226-235, Jan. 26, 1914.)—Two electromagnets are described which are capable of giving fields of 61,500 gauss. They differ considerably from the apparatus of Du Bois and Weiss. In the first form, the conical pole-pieces of a Weiss electromagnet are surrounded by a petroleum-tight box containing a magnetising coil made of

bare flat copper ribbon. A current of 24 amps. is passed through the main windings of the electromagnet, and one of 1100 amps. through the pole windings which are kept cool by means of a current of petroleum cooled to -80°C . The pole windings, which were 28 in number, gave 80,800 amp.-turns in a volume of 29 cm.^3 , and the field due to these was 10,500 gauss, that caused by the main winding being 41,000, or altogether 51,500 gauss, as measured by the Zeeman-effect on the three blue Zn lines. In the second form, a soft-iron cylinder 10 cm. long and 22 cm. in diam. is cut in two by a plane parallel to its base, and a cylindrical cavity is cut out in which the bare wire windings are placed. A cylindrical hole is pierced along the axis of the iron for the optical purposes of the apparatus, and the windings are cooled by cold petroleum as in the first form. This form is excited only by the large current through the copper strip winding, and the whole apparatus weighs about 80 kg. For further particulars the original paper, which contains two full-page diagrams, should be consulted.

G. E. A.

753. *The Ferromagnetic Property as a Function of the Wave-length.* W. Arkadief. (Russian Physico-Chemical Soc., Journ. 45. pp. 108–108 [Physical Part], 1918.)—In the author's experiments on the reflection of electric waves by thin wires in which λ was greater than 8 cm. and less than 80 cm., as also in his experiments on the absorption of waves by parallel wires, where the wave-lengths used ranged between 1.8 and 78 cm., a rapid diminution of the magnetic quality of magnetisable wires was noticed as the short-wave region was approached. With the aid of the results obtained by other workers it is now possible to take a general view of the change which the magnetisability undergoes with change of frequency of the magnetising field; such a view being obtainable from the curves given in the original.

At low frequencies we have a region of constant permeability; at greater frequencies there is a slow falling-off [$10^{-9} < T < 10^{-8}$ sec.; where $T = (\text{frequency})^{-1}$], and at still greater, in the region of the shortest electric waves ($1 < \lambda < 10\text{ cm.}$), the permeability falls very rapidly. The curves show further, that with iron at wave-lengths of a few mm., and with nickel already at wave-lengths of 2 cm. even, the electromagnetic phenomena in ferromagnetic metals occur with a permeability of unity, just as with the long-wave rays of Rubens. These results can be well explained on the hypothesis of the proper vibrations of the Weber molecular magnets.

L. H. W.

754. *Thermal and Galvano-magnetic Effects in Bismuth and the Constants of Drude's Theory.* P. Senepa. (N. Cimento, 6. Ser. 6. pp. 808–825, Nov., 1918.)—According to Corbino [Abstract No. 1597 (1911)], Drude's formula relating to the Hall-effect [Abstracts Nos. 1276 (1900), 840 (1901)] does not correspond with the physical conditions under which such effect is determined experimentally. The author has applied Corbino's modifications of Drude's fundamental equations to the determination of the electronic constants of bismuth, calculations being made of coefficients of the Hall, Ettingshausen and Righi-effects, and of the conductivity. The results obtained tend to confirm Drude's electronic theory of metals, but it is necessary to avoid the use of the coefficient of the Righi-effect, the sign of which is incompatible with the theory; this was previously pointed out by Zahn [Abstract No. 8208 (1904)].

T. H. P.

755. *A Polymorphic Transformation in Fe-Co Alloys.* R. Ruer and K. Kaneko. (Phys. Zeitschr. 15. pp. 17–18, Jan. 1, 1914.)—The iron-cobalt

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alloys undergo, within a certain range of concentration, a change from the γ to the α form, which is accompanied by evolution of heat and change of magnetic permeability. A cylindrical regulus from an alloy of 55 Fe and 45 Co was tested by the magnetometric method in an electric furnace, the specimen being 2 cm. long and 1.5 cm. in diam. Time-temperature and permeability-temperature curves are given for heating and cooling, and these show a discontinuity at 988° C.: in one case, the temperature remains constant at 988° for some minutes during heating and also during cooling; in the other case, there is a drop in permeability at the same temperature on heating, and a rise on cooling. Similar behaviour is shown by 60-40 % Fe and 40-60 % Co alloys, but not by 100 % Fe. The change is not explained by a simple alteration in specific heat, but rather by the transformation of a non-magnetic crystalline form into a ferromagnetic one, the process taking place at constant temperature with change of heat.

G. E. A.

756. Molecular Field and Maurain's Magnetising Action. P. Weiss. (Comptes Rendus, 158. pp. 29-32, Jan. 5, 1914.)—With iron deposited electrolytically in a magnetic field, Maurain [Abstract No. 1112 (1902)] observed that the first layers of the metal are less magnetised than the later ones, these being subjected to a magnetising action by the former. This action may overcome that of a weak external field of opposite sign and may impose its sign on the lower layers. In order to ascertain the variation of this action with the distance, Maurain deposited on the magnetised cathode definite thicknesses of an indifferent metal such as gold, copper, or silver, and then observed the magnetisation of the newly-formed layers in an opposite field of 1.65 gauss. The magnetisation now in question cannot be attributed to an ordinary magnetic field, and since its action depends on the distance according to the same law as holds for the molecular field [see Abstract No. 557 (1914)], it is to be assumed that the two phenomena are identical.

T. H. P.

757. Magnetic Constants of Bismuth Amalgams. T. Gnesotto and M. Binghinotto. (N. Cimento, 6. Ser. 6. pp. 835-847, Nov., 1918.)—Mercury, which has a coefficient of magnetisation $K = (-0.191 \pm 0.001)10^{-6}$, is taken as a standard of comparison for determining the coefficients of magnetisation at the ordinary temperature of a number of bismuth amalgams of different compositions. The magnetic constants were calculated by determining the force exerted on a mass of the substance of definite volume in the middle of the intrapolar space of a field created by exciting one of the two coaxial nuclei of an electromagnet. Increase of the percentage of Bi present from 0 to 0.8 causes a diminution in the value of $K \times 10^6$ from -0.191 to a minimum, -0.188 ; further increase in the proportion of Bi is accompanied by increase in the value of $K \times 10^6$, which reaches -1.460 for pure bismuth.

T. H. P.

758. Variation of Ferro-magnetism with Temperature. P. Dejean. (Soc. Int. Élect., Bull. 4. Ser. 8. pp. 11-38, Jan., 1914.)—A method of thermomagnetic research is described in which the induction in a bar or ring is graphed with the temperature, by Saladin's method, in such a way that the image of a luminous point describes a curve of which the ordinates are proportional to the induction and the abscissæ to the temperature. An alternating magnetising current of sine form was employed, and numerous heating and cooling curves are given for steels of different carbon-content.

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In the *discussion*, **F. Robin** drew attention to the tendency to draw general conclusions from the results of the study of one property of a metal, and gave particular instances in which care was required in translating the effects.

G. E. A.

759. Hall-effect in Liquid and Solid Mercury. W. N. Fenninger. (Phil. Mag. 27. pp. 109-112, Jan., 1914.)—Describes experiments for the detection and measurement of the Hall-effect in mercury, whence it is concluded that in liquid Hg the effect cannot exceed that with a coefficient 0.00002 e.m. unit and that in solid Hg the coefficient cannot exceed 0.000011 e.m. unit, which is about one-fourth that of tin. [See Abstract No. 1879 (1901).]

E. H. B.

760. Terrestrial Magnetism. Perturbations of the Magnetic Declination at Lyons (Saint-Genis-Laval), during the Third Quarter of 1918. P. Flajolet. (Comptes Rendus, 157. pp. 1181-1182, Dec. 8, 1918.)—The working of the tramways has rendered almost impossible the absolute measurement of the vertical and horizontal components. The declination is little influenced by this cause of disturbance. In the original paper a table of observations is given, the reference figures having the following signification :—(0) Calm days ; (1) Days with oscillations, very feeble, 1' to 8' ; (2) Oscillations feeble, 8' to 7' ; (3) Perturbations rather strong, 7' to 15' ; (4) Perturbations strong, 15' to 80' ; (5) Perturbations very strong, < 80'.

E. O. W.

761. Inequalities in the Distribution of Terrestrial Magnetism. P. Idراع. (Comptes Rendus, 157. pp. 1488-1490, Dec. 22, 1918.)—The present paper is an extension of H. Wilde's work published in 1889, which deals with an instrument called the "magnetarium," designed to reproduce the phenomena of terrestrial magnetism. This instrument did not admit of investigation at high latitudes and in particular in the neighbourhood of magnetic poles, but the practical character of Wilde's ideas has led the present author to continue the work. The magnetarium itself consists of two quasi-spherical electric coils placed in the interior of a globe, the axis of one being parallel to that of the earth and the other inclined at 28° 30' to this. By covering the marine surface with sheet iron a remarkable concordance was found between the magnetic elements given by a small compass needle on the globe and the same observed naturally—for example, the existence of the small oval area of zero declination in China, etc. The author has constructed a new apparatus, 50 cm. in diam., in which the current may be conveyed to the interior coils without disturbing the polar regions and so preventing their investigation. Wilde's results are for the most part confirmed, but the polar results are not in accordance with those of nature, the north pole being normal but the south widely divergent. All attempts to adjust the apparatus so as to yield accurate results have failed, since, when the correct position of the pole was established, the values for inclination became irregular. In the neighbourhood of the equator the results were well in accordance with facts. The author concludes that the magnetarium although very seductive in its simplicity of conception, is incapable of giving a complete account of terrestrial magnetism. It does, however, show that anomalies in magnetic distribution are very largely due to the effect of marine magnetism. The primary cause of this is difficult to establish in the present condition of the science, but may well be attributed to inequalities of the terrestrial core, or, at any rate, to a larger proportion of magnetic matter below the maritime regions.

H. H. Ho.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

762. Positive Charges of Atoms. J. Stark. (Phys. Zeitschr. 14. pp. 965-969, Oct. 15, 1918.)—Certain substances which have no valency, chemically speaking, such as helium and argon, may yet be put into the form of bivalent or even trivalent ions as canal-ray particles. The author attributes this to the difference between the detachable chemical "valency electrons" and the more deep-seated electrons which can only be detached by impact, or by the actual penetration of a kathode-ray particle into the interior of the atom. For the same reason, the known range of valency of atoms may be considerably extended, as in the case of mercury, where valencies as high as 7 have been observed.

E. E. F.

763. Atomic Ionisation and Atomic Charge. F. Sanford. (Science, 88. pp. 741-742, Nov. 21, 1918.)—From the atomic mass and velocity in electrolysis the author has made an estimate of the number of electrons in the atoms of H, Cl, Br, and I, and these numbers are now found to bear a constant relation to Kleeman's numbers representing the relative ionisations in these gases by either α -, β - or γ -rays.

E. M.

764. Decomposition of Hydrogen Sulphide by Radium Emanation. E. Wourtz. (Comptes Rendus, 157. pp. 929-931, Nov. 17, 1918.)—The experiments were made with the emanation from 880/mgm. of RaBr and two flasks charged with H₂S gas, the one kept at ordinary temperature, the other cooled down to -220° . The emanation produced a mist from which sulphur condensed; polysulphides were not observed; the hydrogen liberated was determined by immersing the flask in liquid air and passing the non-condensed gas into a burette. The rate of decomposition decreased in the course of an experiment; the pressure (2.2 to 1.4 atmos.) appeared merely to influence the absorption of the emanation by the gas; the rate of decomposition decreased as the temperature rose. The number of H₂S molecules decomposed per α -particle seemed to be 8.8 times the number of ions produced in air under the same conditions. Comparing his results with those of Duane and Scheurer on the decomposition of liquid water by the emanation, the author does not find equivalence.

H. B.

765. Method for Determination of Molecular Weights of Radio-active Emanations, with Application to Actinium Emanation. E. Marsden and A. B. Wood. (Phil. Mag. 26. pp. 948-952, Dec., 1918.)—The method depends on the effusion of the emanation through a hole at pressures so low that the mean free path is large compared with the size of the vessels used. In such conditions $\frac{1}{2}\Omega A(N_1 - N_2)$ mols. will cross from one side of the hole to the other; Ω = mean molecular velocity, A = area of hole, N_1 and N_2 are numbers of mols. of emanation per cm.³ on the two sides. If V_2 is the volume of the vessel into which the emanation effuses, this number = $\lambda N_2 V_2$, where λ is the disintegration constant. In the experiments N_1/N_2 is obtained from ionisation measurements, and the molecular weight deduced from the calculated value of Ω . The value for AcEm is found to be about 240. The

calculated value, however, depends on λ^2 , and λ is only known as yet to within about 2 %. The value indicates, however, that if Ac is derived from the Ur series it must be produced by one of the higher members. E. M.

766. Valency of Radium. H. Freundlich and G. v. Elissasoff. (Phys. Zeitschr. 14. pp. 1052-1057, Nov. 1, 1918.)—The reduction of the electric osmose of water by electrolytes shows a well-marked dependence upon the valency of the ions, being much stronger in multivalent than in univalent ions. This suggests a method of determining the valency of an element which is only available in small quantities. The authors work out a method of observing the flow of the liquid past a bubble in a capillary tube. The amount of the kation need not exceed 0.01 or even 0.001 mgm. Experiments with RaBr put it in the same category as Mg or Ba salts, and its bivalence is thus corroborated. Experiments with actinium remained inconclusive. E. E. F.

767. Question of Separation of RaD from Lead. C. Staehling. (Comptes Rendus, 157. pp. 1480-1482, Dec. 22, 1918.)—RaD was mixed with PbCl₂, and it was found that in the Grignard reaction the ratio of RaD : Pb was not altered in either of the Pb reaction products:—



[See Abstract No. 578 (1914).]

E. M.

768. Glow of Sulphur. W. H. Watson. (Chem. News, 108. pp. 187-188, Oct. 17, 1918.)—The fact that, under certain circumstances, sulphur exhibits a "glow" or phosphorescence has been frequently recorded. The author's experiments furnish the following explanation of this phenomenon. When air passes over sulphur heated at a temperature below its ignition-point, the air becomes charged with sulphur-vapour, which separates as a mist or cloud of very small particles. It is the oxidation of this finely-divided sulphur which gives rise to the phosphorescence, but no evidence is obtainable in support of the view which has been advanced that the glow is accompanied by the formation of a lower oxide of sulphur, such as the monoxide, SO. T. H. P.

769. Mechanical Stimulus to Crystallisation. S. W. Young and W. J. Van Sickle. (Amer. Chem. Soc., Journ. 85. pp. 1067-1078, Sept., 1918.)—In previous papers on this subject it has been shown that crystallisation in supercooled liquids may be forced at any temperature below the melting points, so that there exists no so-called metastable field in which crystallisation can be stimulated only by the addition of a crystal of the new phase. On the basis of thermodynamical considerations, Berkeley [Abstract No. 812 (1918)] arrives at the conclusion that a limit must exist to the supersaturation of a solvent with a solute, his experimental results confirming the view expressed above. The authors now describe experiments on the freezing of supercooled dust-free water by the impact of a hammer falling on an anvil from a gradually increasing height. It is found that the hardness of the impact surfaces increases with continuous use to a max. value, this change being accompanied by augmentation of the sensitiveness; the latter is brought back to its original value by repolishing. All the experiments were made at the maximum sensitiveness. The composition of the hammer and its size exert considerable influence on the results.

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With a stellite hammer and anvil, water may be repeatedly frozen at a temperature rather less than 0.02° below its melting-point, so that if water possesses a metastable limit this lies at less than 0.2° below the melting-point. The following relation has been established: $(\sqrt{M} \times S - \Delta) \theta = \text{constant}$, where M is the mass of the hammer in gm., S the distance of fall in cm., θ the extent of supercooling in degrees, and Δ a constant having the value 8 for steel and 18 for stellite.

T. H. P.

770. Capillary Crystals of Iron-vitriol and Silver. O. Mügge. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 8. pp. 857-864, 1918.)—Capillary crystals of green vitriol sometimes develop from iron pyrites or marcassite, which are irregularly curved, but are sometimes composed of a single individual crystal. They have the appearance of having been squirted from an orifice and of having crystallised immediately beyond it. Similar capillary crystals of silver are formed when silver sulphide is heated to 180° in air or hydrogen, and less readily in indifferent gases.

T. M. L.

771. Liquid Mixed-Crystals. P. Gaubert. (Comptes Rendus, 157. pp. 1446-1448, Dec. 22, 1918.)—Complete series of mixed crystals can be prepared from cholesterol propionate and ethyl anisalamincinnamate from 10:0.5 to 10:16.66. The double-refraction of the mixtures for sodium light increases from $\omega - \epsilon = 0.0177$ to 0.1009. This effect occurs in spite of the fact that the substance added has a positive instead of a negative double-refraction.

T. M. L.

772. Allotropy of Cadmium. I. E. Cohen and W. D. Helderman. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 485-489, Nov. 27, 1918.)—It was pointed out by Matthiessen and v. Bose (Poggendorff's Annalen, 116. p. 858, 1862) that cadmium becomes extremely brittle when heated above 80° . Previous experiments on tin and bismuth have shown that metals may exhibit excessive slowness in undergoing molecular changes at temperatures either above or below their transition-points, and such reluctance to undergo change is regarded as one of the reasons why the allotropy of these metals remained so long undiscovered. Similar behaviour is found by the authors in the case of cadmium. Their first experiments consisted in determining the densities of two samples of "Kahlbaum" cadmium pyknometrically. The changes in density produced by heating the metal at various temperatures for 24 hours, either in an atmosphere of CO_2 or in a dilute cadmium sulphate solution, indicate the existence of a transition temperature between 40° and 70° , and experiments with the dilatometer fix this temperature at $64.9 \pm 0.1^{\circ}$. The expansion accompanying the transition of cadmium- α into cadmium- β at 64.9° explains the disintegration of Cd-wires at 80° observed by Matthiessen and v. Bose.

T. H. P.

773. Influence of the Principal Metallic and non-Metallic Additions on Normal Copper-Tin Bronzes. H. v. Miller. (Métal, 2. pp. 68-72, 1912. Rev. de Métallurgie, 10. pp. 662-667, Dec., 1918.)—Using the method described by Wüst [Abstract No. 500 (1910)] the author has studied the effects of adding Co, Zn, Pb, Sb, Al, Si, Ni, W, P, and Mn, on the contraction of copper-tin bronzes. The strength, working properties and colouring power in a warm solution of liver of sulphur have also been determined and compared with the similar properties of a normal bronze containing 8 % Sn. Generally the

coefficient of contraction of the normal bronze is taken as 0.7 %, but the figure repeatedly determined by the author is 1.5 %. A considerable quantity of zinc (10 %) has to be added before the coefficient of contraction is appreciably diminished. Co, Al, Si, Fe, and Ni increase the contraction. Strength is increased by Co, Ni, and Mn, but is decreased by Sb and excess of Zn. The machining properties are improved by adding 2 % of Sb or Pb, but deteriorated by Mn and Ni. The intensity of the patina formation is diminished by Zn and Al, but increased by the addition of Co, Ni, Sb, Fe, Si, and P. Ordinary bronzes have considerably lower solidification points than bronzes containing W, Ni, Fe, Mn, and Co.

F. C. A. H. L.

774. Researches on Manganese-Silver Alloys. G. Arrivaut. (Rev. de Métallurgie, 10. pp. 1257-1268, Nov., 1918.)—The author has investigated the Mn-Ag system by thermal, microscopic, p.d., and chemical methods. Thermal methods show that the solidifying point of Mn (1285° C.) is lowered to 1180° C. by the addition of about 6 % Ag. Between 94 and 81 % Mn the temperature of deposition of solid remains constant at 1180° C. indicating the existence of two liquid layers in this region. From 81 to 20 % Mn the latent heat of fusion is so small that the solidifying temperature is not indicated on cooling curves. In all these alloys a reaction occurs at 980° C. between solid and liquid, resulting in the formation of the compound MnAg₂. Near the silver end of the series a feeble minimum is reached at 955° C. in an alloy containing 4 % Mn. The absence of an eutectic line indicates that Ag and MnAg₂ form a continuous series of solid solutions. Microscopic examination of the solid alloys confirms these views. Determination of the p.d.'s set up in an electrolyte consisting of a 10 % solution of manganese sulphate against a silver electrode depolarised with manganese dioxide also confirmed the existence of the compound MnAg₂ and indicated the existence of a continuous series of solid solutions between 0 and 20 % Mn. A number of the alloys were powdered and treated with 10 % hydrochloric acid. In every case a brilliant metallic residue was left. It had a sp. gr. of 8.81, was unaffected by the atmosphere of the laboratory, and was unattacked by solutions of sulphuric and hydrochloric acid except when the latter were hot and strong. Chemical analysis showed its average composition to correspond with the formula MnAg₂.

F. C. A. H. L.

775. Brittleness in Lead. O. Bauer. (Königl. Materialprüfungsamt, Mitt. 81. 7. and 8. pp. 857-869, 1918.)—Preliminary tests carried out at various temperatures showed that the resistance of lead sheets to bending slightly decreased up to 160° C. and then increased again up to 260° C. Cold bending tests carried out on lead sheets which had previously been heated for various periods at temperatures between atmospheric and 260° C. showed that the resistance to bending decreased by an amount depending upon both the temperature and time of heating. At 100° C. the reduction was relatively slight (from 22 to 17.8) after 24 days, and even after 41 days the value had only fallen to 17.1. At 260° C., however, the value fell to 12.4 in 10 days and after 17 days had become constant at 11.6. These results have been summed up in a solid model showing the relationship between time, temperature, and the resistance to bending. At the same time grain-growth has been followed by means of the microscope and planimeter. In general, the dimensions of the grains increase with both the time and temperature of heating.

F. C. A. H. L.

776. Constitution of Bismuth-Cadmium-Zinc Alloys. C. H. Mathewson and W. M. Scott. (Int. Zeitschr. Metallg. 5. pp. 1-60, Nov., 1918).—The authors criticise the results of earlier work on the constitution of the Bi-Zn series which furnishes a good example of limited miscibility in the liquid state. Their own results confirm those of Heycock and Neville and show that there is a region of limited miscibility in the liquid state, the concentrations of the two conjugate layers at the temperature of crystallisation (416° C.) being 99.85 and 86.8 atoms per cent. respectively of zinc. The liquidus curves of the Bi-Cd and the Cd-Zn series have also been redetermined. Cd appears to dissolve about 1.5 atoms per cent. Zn, but in the other cases solubility in the solid could not be detected by thermal analyses. In the ternary series about 100 alloys were prepared and studied thermally, the object being to establish the constitution throughout the temperature range of crystallisation without reference to the question of miscibility between liquid phases above this range. The results are summed up in an isothermal diagram which is discussed theoretically from a graphic potential standpoint. Addition of Cd to Zn-Bi alloys lowers the temperature of equilibrium between two liquid layers and Zn. At a critical temperature of 828° C. and a concentration of 6.9 atoms per cent. Bi, 57.1 atoms per cent. Cd and 46.0 atoms per cent. Zn, the two liquid phases mix in all proportions. A ternary eutectic is formed containing 44.3 atoms per cent. Bi, 54.1 atoms per cent. Cd, and 1.6 atoms per cent. Zn. F. C. A. H. L.

777. Influence of Elements on Absorption of Carbon by Steel. R. R. Abbott. (Amer. Inst. Mining Engin., Bull. 82. pp. 2389-2400, Oct., 1918).—The results of 208 experiments on the carburisation (case-hardening) of various steels are used for the calculation of equations and plotting of diagrams to give the rate of carburisation (increase of weight) at 900° C. and 1000° C. Since they are sources of error in the form of equation selected, S, Mn, P, and Si were left out of the final solution and the steels high in silicon were not used in calculations involving more than two variables. Thus the equation for carbon-nickel steels at 1000° C. is $C/1.18 + Ni/89.5 + Wt./265 = 1$. This gives, for example, that a steel containing 8.5 % Ni and 0.20 % C. will absorb C as readily as a steel containing 0.80 % C and no Ni. The equations worked out for C, Ni, and Cr are : at 900° C., $C/0.56 + Ni/6.85 - Cr/58 + Wt./100 = 1$; and at 1000°, $C/0.56 + Ni/6.95 - Cr/80 + Wt./199 = 1$. These are not fully satisfactory when applied to practical interpretations; they would, for example, indicate that a pure iron would absorb 199 mgm. of carbon at 1000° in 10 hours, and 100 mgm. at 900°; as a matter of fact this is too low a value. Manganese at 900° is apparently without effect on the rate of carburisation, and at 1000° it increases with increase of Mn. The other results can only be fully appreciated with the aid of the diagrams and detail figures. The results for various series (Cr-V, Ni, C, and Si steels) show that the rate of absorption of C is lowered to the same extent in all except Si steels by an equal increase of C in the original steel. The relation between original carbon-content and rate of absorption is probably not a straight line. At 900° the effect of increase of original carbon-content in decreasing the rate of absorption is greater than at 1000°. F. R.

778. Influence of Silicon on the Solubility of Carbon in Iron. G. Charpy and A. Cornu. (Comptes Rendus, 157. pp. 901-908, Nov. 17, 1918).—Five iron alloys containing about 2 % carbon and from 2.28 to 6.77 % Si were annealed at 100° C. for 8 hours and cooled very slowly in order to convert the

whole of the carbon into the graphitic form. Small specimens were then cut, heated to various temperatures between 800° and 1000° C. and cooled rapidly. The resulting samples were then tested for total carbon and graphitic carbon contents. The results, which were confirmed by the determination of the Brinell hardness figures, indicate that addition of Si gradually diminishes the solubility of carbon in iron. With 4 % Si the solubility is nil up to 900° C., while with 7 % Si practically no carbon dissolves up to 1000° C.

F. C. A. H. L.

779. Influence of Copper upon Steel. G. H. Clevenger and B. Ray. (Amer. Inst. Mining Engin., Bull. 82. pp. 2487-2475, Oct., 1918.)—The authors found it advisable in making their copper steel ingots in crucibles to kill for some time before adding copper, and to add Al before teeming. The carbon contents of the eight steels ranged from 0.44 % to 0.60 %, and the copper from 0 to 4.51 %. It was only with the highest copper content mentioned that red-shortness occurred in forging. With copper up to 0.85 % the steels welded satisfactorily. The addition of copper appears to have eliminated the sulphur markedly; there was 0.088 % in the ingot with no copper and 0.02 % sulphur in the ingot with 4.51 % copper. With 0.85 % copper the segregation of Cu towards the bottom of the ingot begins to be noticeable, and this increases with the Cu-content. Up to 0.49 % Cu markedly decreases the rate of corrosion in dilute sulphuric acid, but with higher Cu the rate of corrosion becomes greater than when Cu is absent. With increase of Cu the microstructure becomes finer, said to be due to the more even distribution of the carbide. This is more particularly the case in the steels in the forged condition. The critical temperature A_{r1} is lowered by additions of Cu to 685° C. in the steel containing 4.51 % Cu. The elastic limit increases with addition of Cu up to more than double at 4.51 % Cu. The tensile strength also increases progressively, up to about 55 % increase as forged, and about 45 % increase for annealed samples. The elongation of the steels as forged falls to practically nil beyond 8.0 % Cu; in the annealed steels the elongation ranges from 20 to 14 %, including a slight increase above 2.0 % copper. The scleroscope hardness increases with Cu-content, from 28 up to 48 with 4.51 % Cu. Photomicrographs, cooling curves, and a bibliography are given.

F. R.

780. Grain-growth in Silicon Steel. W. E. Ruder. (Amer. Inst. Mining Engin., Bull. 84. pp. 2805-2822, Dec., 1918.)—Grain-growth in silicon steel containing 0.05 % carbon, 0.15 % Mn, 0.088 % P, 0.026 % S, and 8.24 % Si, has been studied by annealing in hydrogen at various temperatures. The results show that growth begins at about 1050° C., the rate of growth then increasing with the temperature. The max. grain-size is determined by the amount and kind of mechanical work, and not by the rate of heating and cooling. Light work produces large grains, heavy work produces fine grains. When once formed the large grains cannot be altered by any heat-treatment short of actual fusion, but can be broken up by mechanical working followed by annealing above 1020° C. The effect of cold work persists even after heating to incipient fusion. In sheets below 0.007 in. thick the grain-growth is only slight.

F. C. A. H. L.

781. Influence of Thermal Treatment on the Properties of Cold-drawn Steel. P. Goerens. (Rev. de Métallurgie, 10. pp. 1387-1359, Dec., 1918.)—Soft steel of the composition 0.08 % C, 0.008 % Si, 0.056 % S, 0.059 % P, and

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0.89 % Mn was drawn down by a reduction of 85 % to wires of 2.7 mm. diam. After annealing at various temperatures up to 1070° C. a study was made of the mechanical properties, flexibility, density, electrical conductivity, thermoelectric properties, rate of solution in dilute sulphuric acid, potential of solution, and the structure of the various samples. The results show that the ultimate strength is sensibly lowered by heating to 100° C. but at 520° C. there is a sudden decrease of strength and a sudden increase in the elongation and contraction. Time is not so important as temperature, but nevertheless its effect increases with the temperature. A long heating at a low temperature does not have the same effect as a short heating at a high temperature. Most of the properties undergo a sudden change at or about 520° C.: the flexibility and density increase while the remanence curve shows a fairly sharp maximum at this temperature. There is also a change in the microstructure at this temperature the nerve-like structure characteristic being replaced by a granular configuration. The conclusions to be drawn from this work are that 520° C. is to be regarded as the limit between cold and hot work. Further, it is not necessary to heat the metal to the temperature of the allotropic changes to remove the effects of cold-working. A short heating at 520° C. restores the metal to its normal state, which renders possible a low fuel consumption and obviates actions detrimental to the quality of the metal, such as oxidation, decarburisation, and so on.

F. C. A. H. L.

782. Calorimetric Study of the Iron-Carbon System. A. Meuthen. (Ferrum, 10. pp. 1-21, 1918. Rev. de Métallurgie, 11. pp. 19-28, Jan., 1914. Extract.)—Although a large number of researches have been carried out to determine the temperatures of the critical changes in the iron-carbon system, little work has been done on the amount of heat exchanged during the reactions which occur. An attempt has been made by the author to fill this gap by series of calorimetric determinations between 950° and 650° C. on 12 fairly pure Fe-C alloys containing 0.06 to 4.08 % carbon. The experiments were carried out in Oberhoffer's original apparatus [Abstract No. 1541 (1908)], consisting of a vacuum electric resistance furnace combined with a Bunsen ice-calorimeter. In the case of materials heated to above 710° C. care was taken to ensure the conversion of the whole of the pearlite into solid solution, and that the cooling in the calorimeter was slow enough to permit of the complete conversion into pearlite was proved by subsequent microscopic examination. Consideration of the results shows that pearlite contains 0.9 % carbon and that its heat of conversion is 15.9 gm.-cals. per gm. at 710° C. The conversion of 1 gm. β to α iron is accompanied by the development of 5.6 gm.-cals., while the separation of 1 gm. α iron from the solid solution gives out 14.1 gm.-cals. Between 650 and 700° C. the heat contents of Fe-C alloys do not show a direct linear relationship with the carbon-content. The concentration-heat curve consists of two straight lines meeting to form a maximum at about 0.97 % carbon. This may bear some relationship to the discontinuity in the specific volume curve observed by Benedicks at 1.26 % carbon, but further experiments at lower temperatures are required to explain this apparently anomalous behaviour which appears to be similar to anomalies observed in the specific heats of Bi-Sn and Bi-Pb alloys.

F. C. A. H. L.

783. Effect of Light on the Electrical Charge of Suspended Particles. S. W. Young and L. W. Pingree. (Journ. Phys. Chem. 17. pp. 657-674, Nov., 1918.)—All the suspensions, emulsions, and colloidal solutions investigated by

the authors show a very distinct light-sensitiveness with respect to their rates of migration in the electrical potential gradient, the effect being positive in some cases and negative in others. This effect is readily explainable in either of two ways: (1) The influence of light is to affect the degree of dispersion of the suspended matter, increasing it in the case of acceleration and decreasing it in the case of retardation; (2) the influence of light is a direct one on the static charge carried by the suspended particles, increasing this charge in case of acceleration and reducing it in case of retardation. Since the velocity of migration of bacteria—the degree of dispersion of which can hardly be regarded as alterable—is diminished by illumination, the second explanation seems to be the correct one.

T. H. P.

784. Kohlrausch's Law of Additivity. G. Boizard. (*Journ. de Physique*, 8. Ser. 5. pp. 701-705, Sept., 1918.)—In consequence of the results obtained by Noyes [Abstract No. 1528 (1908)], Gorke [Abstract No. 1199 (1908)], and Jones and White [Abstract No. 1789 (1910)], the author has modified certain of the values of the equivalent conductivities of the ions in solutions of infinite dilution given by Kohlrausch and Steinwehr [Abstract No. 2290 (1902)] and by Kohlrausch and Grüneisen (*Preuss. Akad. Wiss. Berlin, Ber.*, 1904). The experimental numbers obtained for the conductivities of a large number of electrolytes are then compared with the values calculated from the corresponding ionic conductivities according to Kohlrausch's law of additivity. With strontium chloride the divergence is 1.9 per cent., and with potassium acetate 1.2 per cent., but apart from these cases the chlorides, nitrates, and sulphates, and also sodium and potassium salts, show agreement in every instance to within ± 0.5 per cent. The least concordant series is that of the acetates, with which the accuracy does not exceed 2 per cent. The value for the hydroxyl ion in c.g.s. units at 18° is $170 \times 10^{-9} \pm 1$ per cent., and that for the hydrogen ion $815 \times 10^{-9} \pm 1$ per cent. [See also Drucker, Abstract No. 1605 (1907).]

T. H. P.

785. Concentration and Conductance of Ionised Substances in Various Solvents. C. A. Kraus and W. C. Bray. (*Amer. Chem. Soc., Journ.* 85. pp. 1815-1484, Oct., 1918.)—The relation between concentration and conductance may be expressed by the equation— $c(\gamma)^2/c(1-\gamma) = K + D(c\gamma)^m$, where c is the concentration, γ the conductance-ratio Λ/Λ_0 , and K , D , and m are constants. In sufficiently dilute solutions the term $(c\gamma)^m$ become negligible in comparison with K , and the equation approaches the simple mass-law action as a limit. In concentrated solutions K becomes negligible in comparison with $D(c\gamma)^m$, and the equation becomes that of Storch. For $m > 1$ the molecular conductance passes through a minimum; for $m < 1$ it decreases continuously with increasing concentration. The constants of the equation may be evaluated by graphical methods. It applies not merely to aqueous solutions, but also to the extensive data for solutions in liquid ammonia.

A method is described for testing the law of mass-action without assuming a value for Λ_0 . Deviations, in the case of liquid ammonia, become appreciable at ion-concentrations from 0.001 to 0.0001 normal; therefore the smaller the ionisation the higher the total concentration up to which the law is obeyed. The equation can also be applied to solutions in sulphur dioxide. The influence of temperature can be accounted for by variations in the constants.

In the case of strong electrolytes in non-aqueous solvents (including the

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higher alcohols) the law of mass-action applies up to ion-concentrations 0.001 to 0.001 normal, the limit being approximately the same for a given electrolyte in different solvents and for different electrolytes in the same solvent.

In concentrated solutions in solvents of low ionising power, $1 - \gamma$ is nearly equal to unity and varies slowly in comparison with γ . This leads to the simplified equation, $c\Lambda^2 = P(c\Lambda)^m$, where P is a constant involving Λ_0 . It has been found to hold good for all cases (67 solutions and 12 solvents) for which reliable data exist.

Coming now to aqueous solutions, the equation expresses the conductance of KCl between 0.001 and 2.0 normal within 0.1 per cent., but in the more dilute solutions it is necessary to assume $\Lambda_0 = 128.8$ instead of 180.1. The accepted values of Λ_0 are probably all 1 to 2 per cent. too high, as they have been determined by extrapolation by means of an arbitrary dilution-law.

As regards the constants in the equation—with decreasing dielectric constant, K approaches zero (or a very small value), D approaches a constant value (0.85), which changes little as the dielectric constant falls below 22, and m increases to a value greater than 2. The marked conductance of concentrated solutions in solvents of low dielectric constant is due to the large value of D .

To sum up: all solutions of all binary electrolytes obey the same law; the mass-action law is obeyed at high dilutions; the divergence at higher concentrations is a function of the ion-concentration, and is to be attributed to the interacting forces produced by charge particles (ions) in the solution; for a given electrolyte the trend of the conductance-curve is determined by the dielectric constant of the solvent. Finally Arrhenius' method of measuring ionisation by the conductance ratio Λ/Λ_0 is valid even in concentrated solutions, beyond normal if the influence of viscosity is taken into account.

T. M. L.

786. Chemical Reactions and Electrical Conductivity in Non-aqueous Solutions. H. P. Cady and H. O. Lichtenwalter. (Amer. Chem. Soc., Journ. 85. pp. 1434-1440, Oct., 1918.)—Kahlenberg has suggested that instantaneous reactions between hydrogen chloride and solutions of copper, nickel, and cobalt oleates in benzene occur without conductivity or ionisation, and in defiance of the theory of electrolytic dissociation. Analogous experiments are now described with a series of very carefully-dried solutions and carefully-dried hydrogen chloride.

Copper oleate dissolved in toluene and lead erucate in benzene (both salts containing *one* double-bond) at once produced a great deflection of the galvanometer; addition of hydrogen chloride produced further great increased conductivity followed by precipitation of copper or lead chloride and a disappearance of the conductivity. On the other hand, the salts of two saturated acids, lead stearate in toluene and copper and silver melissates in benzene, produced some conductivity, increased by hydrogen chloride, but gave no precipitate. Barium linoleate (containing two double-bonds) dissolved in benzene behaved like the other unsaturated acids.

In no case was the reaction instantaneous. It is suggested that the reactions with unsaturated acids involve (1) addition of hydrogen chloride, and (2) molecular rearrangement with formation of the metallic chloride and free acid: this could not occur with the saturated salts. It is claimed that all these observations are in agreement with the theory of electrolytic dissociation.

T. M. L.

787. Kinetic Energy of Particles in Colloidal Solution. A. Westgren. (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 5. pp. 1-36, 1918.)—The influence of polydispersivity of a sol on the distribution of its particles in the case of sedimentation equilibrium is investigated theoretically, the impossibility of an exponential relation of the concentration to the magnitude of the polydispersivity being proved. The results previously obtained by Svedberg, Inouye, and the author on the compressibility of disperse systems were made use of to calculate the distribution of the particles of a sol; if such results are correct, the distribution must differ considerably from the exponential relation. But the distribution curves now obtained with virtually monodisperse selenium and gold sols are distinctly exponential in character, so that the results referred to above must be regarded as inaccurate. The compressibility determined by the variations of concentration with time within an optically limited volume are then only apparent, and the deviations from the compressibility to be expected if Boyle's law holds are due to hydrodynamic effects. T. H. P.

788. Surface Tension and Hydration in Solution. M. Padoa and G. Tabellini. (Accad. Lincei, Atti, 28. pp. 88-94, Jan. 18, 1914.)—To the study of hydration in solution the authors have applied measurements of the surface tension, and more especially its temperature-coefficient, which has been shown by Eötvös to depend on the degree of polymerisation of the solvent. The surface tension has been measured by Morgan and Higgins' method of determining the weight of the drop falling from the end of a glass tube of definite dimensions [Abstract No. 1519 (1908)]. Solutions of various concentrations of ammonium chloride, cobalt chloride, sodium bromide, magnesium chloride, and hydrochloric acid were examined at different temperatures. With hydrochloric acid solutions, exceptionally low values were obtained for the Eötvös constant, and the author concludes that hydrates of hydrogen chloride are formed. T. H. P.

789. Polarisation Capacity of an Electrode under an Alternating E.M.F. and a Method of determining it. P. Vaillant. (Comptes Rendus, 157. pp. 1141-1148, Dec. 8, 1918.)—Under an alternating e.m.f. less than the limit for polarisation a voltmeter may be regarded as consisting of two capacities in series. The author has made experiments to determine the capacity of a voltmeter containing a (nearly) normal solution of sodium chloride in water, using Pt-wire electrodes. The method adopted was a null one in which a Curie electrometer was used as indicator, the capacity under observation being obtained in terms of three others of known value, two of which were variable. Using Pt-wire electrodes of 0.1 mm. diam., placed at a fraction of a mm. from each other, it was found that starting with a small e.m.f. and gradually increasing it, the capacity diminished at first, passed through a minimum at about 0.15 volt, and then increased nearly linearly up to 1.2 volts. For a pressure of 1.74 volts the capacity becomes infinite. For an effective pressure of 0.5 volt between an electrode and the electrolyte the capacity is of the order of 10 mfd. per mm.² area of electrode. W. C. S. P.

790. Nickeling of Aluminium. J. Canac and E. Tassilly. (Comptes Rendus, 158. pp. 119-121, Jan. 12, 1914.)—The aluminium is immersed in a bath of boiling potash solution, then brushed with milk of lime and left for some minutes in a 0.2 per cent. potassium cyanide solution, each of these
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treatments being followed by thorough washing with water. The metal is next left in a bath composed of 500 c.cm. of water, 500 gm. of hydrochloric acid and 1 gm. of iron until it assumes a "watered" appearance. It is then ready to receive an electrolytic deposit of nickel, the chloride giving a better bath than the sulphate. The coating thus obtained has a matt white appearance and can be readily polished with a scratch-brush, while it can be hammered without cracking, and can be heated to the melting-point of Al without separating from the latter. Comparative measurements of the magnetic susceptibilities of the Al before and after treatment with the iron bath show that the amount of iron deposited is very small, Féry's spectrophotometer giving from 0.25 to 0.50 gm. of iron per sq. metre. Microscopic examination reveals the existence of numerous pits in which the nickel is fixed during the subsequent electrolysis. The nickeled aluminium does not change in moist air and resists the action of dilute soda solution, glacial acetic acid or concentrated sodium chloride solution, either hot or cold. It shows no Kelvin-effect, but the coefficient of expansion of the Al is lowered by nickeling.

T. H. P.

791. Fine-meshed Brass Gauze as a Substitute for Platinum in Electro-analysis. D. F. Calhane and T. C. Wheaton. (Metallurgical and Chem. Engin. 12. pp. 87-89, Feb., 1914.)—Brass wire gauze (100 meshes per linear inch) has been used by the authors, over a period of two years, in the electrolytic estimation of copper, zinc, and nickel. The kathode used was made from a piece of gauze, $5\frac{1}{2}$ in. by $8\frac{1}{2}$ in., the longer edges of which were lapped over and hammered down, and the shorter ones bent over a 12-in. loop of copper wire (22-gauge) the ends of which were afterwards twisted together. The cylinder thus formed was thinly plated with copper, then washed, dipped in alcohol, dried and weighed for use. The anode consisted of a spiral made from 10-12 in. of platinum wire weighing about 1 gm. In the case of ammoniacal solutions, the copper wire stem of the kathode had an insert of Pt-wire, two pieces of which, each 8 in. long, were attached to the gauze, twisted together, and so joined to the stem. Brass gauze could not be used in the separation of silver from copper in cyanide solution, as the zinc dissolved and silver was deposited; but in all successful cases the efficiency of the brass was equal to that of Pt-gauze, the time factor for the former with still electrolyte being nearly as good as that for the latter with magnetic stirring. Details are given of the procedure followed in the electro-analysis of copper scale and various alloys of nickel, copper, and zinc.

T. S. P.

792. Electrolysis of Aqueous Solutions of the Simple Alkaline Cyanides. G. H. Clevenger and M. L. Hall. (Amer. Electrochem. Soc., Trans. 24. pp. 271-289; Discussion, pp. 289-296, 1918.)—As a result of their experiments the authors come to the conclusion that the bulk of the decomposition of cyanide occurring during electrolysis is due to oxygen liberated at the anode through the decomposition of water. The principal final reaction in solutions containing protective alkalinity, which in cyanide-mill practice is usually due to lime, is the formation of the corresponding alkali carbonate, this accounting for the formation of large amounts of calcium carbonate during the electrolytic precipitation of gold and silver from cyanide solutions.

T. S. P.

793. *Electrolysis of Cyanide Solutions.* E. F. Kern. (Amer. Electrochem. Soc., Trans. 24. pp. 241-265; Discussion, pp. 265-270, 1918.)—The electrolysis of cyanide solutions by direct current, using insoluble anodes, is accompanied by progressive consumption of cyanide, which is oxidised to oxy-cyanide compounds. Anodes of iron, nickel, and lead are dissolved during such electrolyses, the lead then being precipitated as hydroxide and the iron and nickel as a mixture of hydroxide and cyanide compounds. Using these attackable electrodes, the consumption of cyanide is relatively greater the lower the current density, since with high current densities oxygen is also liberated and, consequently, less metal dissolved. The consumption of cyanide is less with lead than with iron or nickel anodes. Peroxidised lead and "passive" iron anodes are more permanent than anodes of either iron, nickel, or lead, the "passive" iron anodes giving the best results. When the cyanide solutions contain sulphocyanides or ferrocyanides, the cyanide consumption is much less than with pure cyanide solutions; the consumption is also diminished by increased alkalinity of the solutions. The lower the current density at the anode and the higher it is at the kathode, the greater relatively is the cyanide consumption. The electrolysis of cyanide leach solution was not found to be beneficial in commercial operations, either in reducing the cyanide consumption or in increasing the percentage extraction. T. S. P.

794. *Solid, Thick Deposits of Lead from Lead Acetate Solutions.* F. C. Mathers. (Amer. Electrochem. Soc., Trans. 24. pp. 815-829, 1918.)—The author has investigated the electro-deposition of lead from various solutions of lead acetate, and shows that, if the proper addition agents are introduced, solid, dense, coherent deposits can be obtained, thus disproving the statement of Betts that "no good deposit has ever been obtained when the basis of the electrolyte is a weakly-dissociating acid." The addition agents were both inorganic and organic, and photographs of the deposits are given. It is probable that any soluble lead salt will give dense, coherent deposits if the proper addition agents are used. [See Abstract No. 2018 (1918).] T. S. P.

795. *Simultaneous Determination of Copper and Lead with the Rotating Anode.* A. J. White. (Amer. Electrochem. Soc., Trans. 24. pp. 297-303; Discussion and Communications, pp. 303-306, 1918.)—The author finds that when less than 0.15 gm. of lead is present with 0.60 gm. of copper, the two metals are quantitatively deposited from a sulphuric-nitric acid solution in 80 mins. by a current of 8 amps. at 6 volts. The best proportions of acid are 4 c.cm. of concentrated nitric acid and 10 drops of concentrated sulphuric acid in a volume of 70 or 80 c.cm. A rotating, roughened dish anode is used to deposit the lead dioxide on, the kathode also being a Pt-dish. The application of the method to the analysis of brass and other alloys is described. [See Abstract No. 1916 (1918).] T. S. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1914.

GENERAL PHYSICS.

796. *A New Piston Air-pump.* W. Gaede. (Phys. Zeitschr. 14. pp. 1288-1240, Dec. 1, 1913. Paper read before the 85. Naturforscherversamml., Wien.)—The new air-pump consists of four air-pumps vertically one above the other, worked by the same piston rod and enclosed in the same cylinder. Water-vapour is not got rid of by means of deliquescent substances, but by means of a special tissue through which the air passes. The vacuum can be brought to 0.00005 mm. within a few minutes. E. E. F.

797. *Electrical Measuring Machine.* P. E. Shaw. (Inst. Mech. Engin., Proc. 2. pp. 579-626; Communications, pp. 625-629, March-April, 1918. Elect. Rev. 78. p. 127, July 25, 1918. Electrician, 72. pp. 9-11, Oct. 10, 1918. Abstract.)—The author summarises the results of his paper as follows:—

(1) A new measuring machine is described founded on the principle of electric touch [see Abstracts Nos. 1116 (1906), 718 (1911)]. It is applicable to the measurement of regular solid bodies, *e.g.* cylindrical, spherical, or parallel-faced, whether metallic or non-metallic. The present machine embodies improvements found desirable in the earlier machine. (2) The solid to be measured is firmly held in a clamp. It can be adjusted in azimuth and elevation and so set parallel to the line of measurement. It can also be run into position by movements perpendicular to its length. For comparison, two solids can be clamped side by side. (3) The unit of measurement is 0.1μ ($= 10^{-5}$ mm.), and comparative readings can be relied on to this amount. (4) The actual length of a solid as compared with a line-standard can be obtained. (5) The parts of the machine directly involved in the measuring are susceptible of adjustment; and the errors arising in taking measurements can be estimated. (6) The machine has been chiefly used for testing and measuring engineering gauges. The Johansson gauges are so regular in figure that the usual measuring machine cannot detect any irregularity in them. With the present machine, errors of the order 0.2μ can be proved to exist.

L. H. W.

798. Viscosity of Undercooled Water. G. F. White and R. H. Twining. (Amer. Chem. Journ. 50. pp. 880-889, Dec., 1918.)—A new viscometer is described which is specially adapted to measure the viscosity of a liquid over a wide range of values. The time of flow both upwards and downwards under a given pressure is measured, thus eliminating some of the usual corrections. The values for the viscosity of water from 0 to 20° differ only by 0.00008, or 1 part in 400 from those given by Bingham and White. At and below 0° the values are—

0°	— 2.10°	— 4.70°	— 6.20°	— 7.28°	— 8.48°	— 9.80°
0.01798	0.01880	0.02121	0.02250	0.02341	0.02458	0.02549

T. M. L.

799. Thermal Coefficient of Micrometer Screw. G. Bigourdan. (Comptes Rendus, 158. pp. 219-220, Jan. 22, 1914.)—The ordinary method of determining the temperature variation of a micrometer screw on an astronomical instrument is to measure the difference of declination of two conveniently situated stars with the same instrument in winter and summer. Some uncertainty is introduced in the exact focusing of the star image, and the author proposes to use the delicate focusing device described recently by Lippmann [Abstract No. 640 (1914)]. When this is done it will then only be necessary (1) to measure the linear value of one turn of the screw, and the coefficient of its expansion; (2) to measure the variation of focus of the objective with temperature, with reference to the tube holding it.

C. P. B.

800. Calibration of Repsold Meridian Circle. P. Harzer, H. Kobold, and O. Tetens. (Zeitschr. Instrumentenk. 84. pp. 20-28, Jan., 1914.)—Notes of tests made on the calibration of the divisions on the limb of a Repsold meridian circle. A summary is given showing the variations at various positions.

C. P. B.

801. Use of Spring Manometers in the Measurement of Large Forces in Testing. A. Martens. (Zeitschr. Vereines Deutsch. Ing. 58. pp. 201-206, Feb. 7, and pp. 808-807, Feb. 21, 1914.)—As a result of continued observation the author has arrived at the conclusion that if the precautions mentioned in the original are observed the spring manometer is a perfectly reliable apparatus for the measurement of water pressure in testing machines and can be employed alone, without any weights, for the determination of the force exerted in testing machines, thus permitting of a considerable simplification in the construction.

L. H. W.

802. Note on the Setting of a Mercury Surface to a Required Height. M. H. Stillman. (Bureau of Standards, Bull. 10. Reprint No. 214. pp. 8-6, 1914.)—The method described is designed for use with Fortin barometers and in other cases where it is desired to set a mercury surface accurately to a level which is indicated by a pointer projecting vertically downwards from above. A scale ruled with parallel horizontal lines is fixed in a vertical plane immediately behind the mercury so that the reflection of the lines is seen in the surface. As soon as the pointer touches the surface the resulting "dimple" is indicated in a pronounced manner by the distortion of the reflected lines. The average variation in the setting of the surface can be reduced by adopting this device to about one-tenth of its value under the ordinary method.

J. S. Dr.

803. *The Testing of Barometers at the U.S. Bureau of Standards.* (Bureau of Standards, Circular No. 46. pp. 8-12, 1914.)—Describes the tests which are carried out by the Bureau. Useful general information is given as to errors and their avoidance.
L. H. W.

804. *Technique of High-pressure Experimenting.* P. W. Bridgman. (Amer. Acad., Proc. 49. pp. 627-648, Feb., 1914.)—Presents the results of several years' experience in designing and using high-pressure apparatus (12,000 to 80,000 kg./cm.²). The following parts are dealt with in detail:—Packing of piston, actuating of piston, cylinders, connecting pipes, pressure gauges, valves, and plugs. [See Abstract No. 1804 (1918).]
H. S. R.

805. *Causes of Error in Shock Tests and the Idea of Brittleness.* A. Mimey. (Rev. de Métallurgie, 10. pp. 1239-1256, Nov., 1918.)—The subject is discussed at some length, with examples, but does not lend itself to brief treatment.
L. H. W.

806. *New Compensation Methods and Thermal Adjustment.* J. Andrade. (Comptes Rendus, 158. pp. 471-478, Feb. 16, 1914.)—The author discusses three methods for avoiding the use of the open flexible ring hitherto employed for compensation purposes, since Phillips has shown that even in a single vibration of the balance of a marine chronometer a strong disturbance of isochronism is set up. This is an extension of previous work on the regularity of action of spiral systems, and Guillaume has succeeded, in the case of pocket watches, in using a rigid balance in association with a compensation spiral. If, for example, a system of palladium spirals be used, whose secondary error is negligible, the elastic loss must be compensated, as this is appreciably greater than the simple thermal expansion, and a compensating mass must be introduced for this purpose. The latter forms the basis of all three methods. The first employs two metals in contact of different dilatability, the second involves the use of mercury reservoirs on two or four of the balance-arms, and the third utilises a cone and spring system which operates as a lever carrying the compensating mass. The two former methods are recommended by the author for practical purposes.
H. H. Ho.

807. *Work of the Royal Dépôt for Testing Materials (Materialprüfungsamt) for 1912.* (Königl. Materialprüfungsamt, Mitt. 81. 5. and 6. pp. 221-286, 1918.)—The information given covers the whole range of subjects investigated. It is possible here only to refer to a few of the more interesting results obtained in the testing of metals. Thus for cast iron the test should always be carried out according to the methods proposed by the German Association for Testing Materials, according to which cast circular rods 80 mm. in diam. and 650 mm. in length are to be used, supported at points 600 mm. apart and loaded in the middle, the breaking load and deflection at rupture being determined. These trials are supplemented in two cases by tension and compression tests on the broken halves of the test-piece. The following values were found:—

Strength in bending test	$\sigma_B = 4170$ and 2830 kg./cm. ² .
Deflection.....	$\delta = 0.98$ „ 0.9 cm.
Tensile strength	$\sigma_B = 2140$ „ 1410 kg./cm. ² .
Elongation	$\delta = 0.5$ „ 0.4 %.
Strength in compression	$\sigma_B = 9000$ kg./cm. ² .

The coefficient of expansion was determined for 5 sorts of cast iron at various
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temperatures. No difference was observed between the different sorts, the mean values being :—

20° to 75° C. : 0·0000107,	150° to 200° C. : 0·0000119,
75° to 150° C. : 0·0000118,	200° to 250° C. : 0·0000126,

Tests were made on glass and on porcelain cubes of 10 cm. side. The glass cubes showed a mean strength of 747 kg./cm.², a somewhat higher value being obtained after exposure to frost (— 14° C.). Porcelain, on the other hand, showed 1590 kg./cm.² at room temperature and only 1106 kg./cm.² when exposed.

Several woods were tested which had been taken from an aeroplane that had failed. Ash gave values ranging from 355 to 432 (mean 405) kg./cm.² in compression; strength in bending, 945 kg./cm.². These figures compare with 428 and 753 kg./cm.² respectively found by Wiykander and with 535 and 999 kg./cm.² found by Janka for American ash. Red deal (Kiefernholz) gave values ranging between 898 and 635 (mean 537) in compression, and 826 to 1016 (mean 940) kg./cm.² in bending tests. Earlier tests from 810 experiments had given mean values of 498 in compression and 991 to 1265 kg./cm.² in bending tests. For pitch pine the figures are : in tension 566; in compression 460 kg./cm.². An aluminium bronze cable composed of 6 wires and one core wire, for use as an electrical conductor, showed that the strength of the cable was equal to the sum of the strengths of the component wires. The wires showed $\sigma = 7630$, $\sigma_B = 10,080$ kg./cm.², with an elongation of 8·1 % on a length equal to 85 diams.

Tests were carried out on two steel balls placed one vertically over the other. For 2-in. balls 118,200 kg. was found; for 2½-in. balls 186,200 kg. Electrically produced steel was also investigated as regards its torsional rigidity. The proportionality limit σ_p ranged from 1720 to 2780 kg./cm.²; the shearing modulus from 800,000 to 850,000 kg./cm.²; elastic limit, σ_s , from 2920 to 8950 kg./cm.²; the breaking strength, σ_B , from 7190 to 8470 kg./cm.². The breaking strength is of small importance, since fracture occurred only after numerous twistings. Lamp filaments (metallic) were investigated as regards the determination of flexibility after different lengths of time they had been running. The resistance to bending was found to be exhausted after about 800 to 1000 hours' running. Carbon electrodes of 40 cm. × 40 cm. cross-section, joined together by means of screw nipples, were tested in tension. The nipples broke at tensions of 20 to 25 kg./cm.². L. H. W.

808. *Mechanical Basis*. H. M. Dadourian. (Amer. Journ. Sci. 87. pp. 157–169, Feb., 1914.)—Both for statics and dynamics the author proposes to make the following single principle the foundation of mechanics :—The sum of all the external actions to which a body (system) or a part of a body (system) is subject at any instant vanishes. $\Sigma A = 0$. In the case of acceleration the product, Mass into reversed acceleration is reckoned as one of the actions. E. H. B.

809. *Einstein's Gravitation Theory*. G. Mie. (Phys. Zeitschr. 15. pp. 115–122, Feb. 1, and pp. 169–176, Feb. 15, 1914.)—A highly analytical treatment of this new theory of gravitation, which is connected with the hypothesis of a variable speed of light and a modified form of the relativity theory. *Erratum*. (Ibid. p. 268, March 15, 1914.)—[See Abstract No. 840 (1918).] A. Einstein. (Ibid. pp. 176–180, Feb. 15, 1914.)—A mathematical discussion in reply to Mie. E. H. B.

810. Structure of the Atom. W. Peddie. (Phil. Mag. 27. pp. 257-268, Feb., 1914.)—The paper is directed to substantiating the author's claim at the 1912 British Association discussion on spectra that, with rotating spherical distributions of electricity as constituents of the atoms, the available constants can be determined so as to account for the observed variations of spectra under different physical conditions without infraction of the hitherto accepted dynamics. J. J. Thomson's recently suggested atomic mechanism [Abstract No. 14 (1914)] accounts for many of the peculiarities in question. Structural atomic conditions can also account for the non-entrance, at ordinary temperatures, of more than five of the freedoms of a molecule of a diatomic gas in molecular interchanges of energy, showing that an exception to the equipartition law does not necessarily involve the violation of accepted dynamical laws.

A centrally symmetrical atom is posited, having regions of attractive force to meet the conditions of stable electron circulation, alternating with regions of repulsive force to meet the conditions of electron expulsion without necessary absorption of much radiation energy; and the total work done by the repulsions on an ejected electron must exceed that done by the attractions by the amount necessary to account for the speed of ejection. The law of radial force-variation must be such as to account for any observed spectrum series. Many structural arrangements can be devised to fulfil these conditions. The one here considered is the spherical counterpart of the Thomson atom referred to above. Such an atom accounting for Balmer's H series is shown to account completely for the readiness with which weak ultra-violet light or Röntgen radiation can liberate electrons possessing the energy quantum. The quantum comes, not from the radiation, but from the energy of the electron when it enters the atom, and is stored for future use. With surface distributions of electricity arranged to give thin shells in which stable circulation of an electron is possible, the resultant force upon an electron in all other regions will be ejective, so that an electron entering the atom with a moment of momentum opposed to that of the shells determining the field must be ejected. This applies also to any electron whose path is inclined at more than a very small angle to the equatorial plane of the atom. Such an atom provides a possible physical basis for the magneton, and, if different stable arrangements with direct or reverse alignment of the shells be possible, conditions will exist in which fundamental changes in spectra may occur. The existence of more than one stable condition requires more than three shells, and such an atom might be magnetic or non-magnetic, so that the non-magnetic condition of a substance might possibly arise, not only from counteraction of the effects of individually magnetic atoms, but also by counteraction of the effects within the atom. Radio-activity might be caused by slowing down of the angular velocities producing rearrangement of the alignment of axes. Under sufficient shock a series of shells might be ejected together, e.g. an α -particle or He-atom.

G. W. DE T.

811. Constitution of Atoms and Molecules. III. N. Bohr. (Phil. Mag. 26. pp. 857-875, Nov., 1918.)—The first two Parts have already been dealt with [Abstracts Nos. 1980 (1918), 15 (1914)]. The present Part deals with systems containing several nuclei, on the same lines as in the earlier papers.

L. H. W.

812. Structure of the Atom and Intra-atomic Electrons. A. van den Broek. (Nature, 98. pp. 7-8, March 5, 1914.)—Referring to Nicholson's VOL. XVII.—A.—1914.

conclusion [*Ibid.* 92. p. 680, Feb. 5, 1914] that the atoms of Li, Ba, and B cannot consist of 8, 4, 5 electrons rotating round a nucleus of 8e, 4e, 5e, respectively, with equal angular momenta in one circular orbit, the author points out that his theory [Abstracts Nos. 567 and 569 (1914)] leads to the same result, as, instead of 1, 0, 1, 2, 8 electrons of valency we should then expect a regular increase from 0 to 5, or no valency. No atomic model, as far as he knows, has accounted for this. He then enumerates a number of applications of his theory to observed phenomena, and claims that the construction of an atomic model is not essential to its validity. G. W. DE T.

813. *Kinematics of Born's Rigid Body.* L. Föppl and P. Daniell. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 4. pp. 519-529, 1918.)—Four-dimensional analysis. E. H. B.

814. *Ship Resistance: the Wave-making Properties of, Certain Travelling Pressure Disturbances.* T. H. Havelock. (Roy. Soc. Proc. Ser. A. 89. pp. 489-499, Feb. 2, 1914.)—Mathematical; mainly with reference to G. S. Baker and Kent (*Inst. Naval Architects, Trans.* 1918).

815. *Deep Water Waves.* J. R. Wilton. (Phil. Mag. 26. pp. 1058-1059, Dec., 1918, and 27. pp. 885-894, Feb., 1914.)—Mathematical.

816. *Viscosity of Liquids under High Pressure.* O. Faust. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 4. pp. 489-508, 1918.)—Measurements of viscosity have been made up to a pressure of 8000 kg./cm.², in a steel bomb, using electrical contacts to mark the flow of the liquid. Values were obtained for ether at 0°, 20°, 84°, for carbon disulphide at 0°, 20°, and 40°, and for ethyl alcohol at 0°, 20°, 40°, and 54°. The viscosities increase very greatly with the pressure, on the average about fourfold by increasing the pressure from 1 to 8000 atmos. In the field of small volumes, in which according to Tammann the molecular attraction is constant, the viscosity tends to become a simple linear function of the volume. T. M. L.

817. *Molecular Transformation of Thin Layers on Water.* H. Labrousse. Comptes Rendus, 158. pp. 627-629, March 2, 1914.)—When an attempt is made to spread a solid substance in a thin layer on water by means of a suitable volatile solvent, it is often found that the substance liberated from the solvent agglomerates into scattered visible grains. Experiments with a number of substances melting between 0° and 100° show that, with all of these excepting the highly volatile tribenzoin, temperature has a very definite and important action. The results of these experiments are expressed as curves having temperatures as abscissæ and quantities proportional to the surfaces covered as ordinates. With trimyristin spread on the surface of water by means of toluene, the curve at first runs almost parallel with the axis of abscissæ and then gradually rises, the values of the ordinate being about 18 at 20° and about 28 at 80°; subsequently the curve again becomes practically horizontal. The range of temperature over which this transformation takes place, namely about 18-81°, is far removed from the melting-point of the trimyristin, 53°, at which no particular variation of the surface covered occurs. Similar results are obtained with the other substances examined, the ratio between the surfaces covered in the hot and in the cold being in all cases about 8:2. The change takes place in the opposite direction on cooling, and is repeated on subsequent heating, and so on.

T. H. P.

818. Measurement of Surface Tension of Soap Films. G. F. C. Searle. (Cambridge Phil. Soc., Proc. 17. pp. 285-299, Sept. 8, 1918.)—An account is given of some methods employed at the Cavendish Laboratory for the measurement of the surface tension of soap solution. The methods described are: (1) The *Torsion balance method*, in which a rectangular frame of wire is dipped into a soap solution and the pull of the film is measured by aid of a simple torsion balance. The value of the surface tension was found to be 27.22 dynes/cm. by this method. (2) The *Thread method*, in which the surface tension is deduced from the curvature produced in flexible threads dipped in the solution. The surface tension by this apparatus was found to be 27.17 dynes/cm. (3) The *Viscosity Potentiometer method*, in which the pressure excess due to a spherical soap film is measured, the result found in this case being 25.19 dynes/cm. (4) The *Buoyancy method*, which was suggested by the plan adopted in the calibration of the author's new micro-manometer. It depends upon the difference of density between cold and hot air at the same pressure. By this method the value of the surface tension of the solution was found to be 27.07 dynes/cm. J. J. S.

819. Liquid Films. W. Mieh1. (Phys. Zeitschr. 14. pp. 1218-1222, Dec. 1, 1918.)—Some new experiments are described with soap films, hinged aluminium wires, and silk threads. A number of geometrical propositions involving minimum areas are illustrated by the shapes into which the soap films contract. E. E. F.

820. Electrically-generated Movements of Liquid Films. S. Mikola. (Phys. Zeitschr. 15. pp. 211-218, Feb. 15, 1914.)—Describes the movements of films of soap solution when a current from a high-potential battery traverses them. The films were formed on an insulating frame, and the battery terminals connected to wires projecting into the film. The motion generally consists of double eddies, the phenomena having many similarities to electric endosmose. Photographs are reproduced. A. W.

821. Microseismic Periods. C. Mainka. (Phys. Zeitschr. 14. pp. 1285-1286, Dec. 15, 1918.)—Gives a set of curves showing the distribution in time of microseismic oscillations in Irkutsk and Pultovo. All periods between 8 and 7 seconds are equally frequent about the end of March. In mid-summer the short periods are most frequent, and in mid-winter the longer periods (6 or 7 secs.). E. E. F.

822. Thunderstorms as a Cause of Seiches. T. Okada, S. Fujiwhara, and S. Maeda. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 210-221, Jan., 1914.)—The paper contains the results of an inquiry into the mechanics of the action of thunderstorms in causing seiches in Lake Biwa in Central Japan, based on records made with a limnometer of the Honda pattern. A list of the most important causes is given, viz., impacts of the falling rain-drops on the surface of the lake, accumulation of rain-water on one portion of the lake, impulsive action of winds on the surface, release of electric attraction of thunder-clouds, sudden changes of the barometric pressure, and their relative importance in generating seiches is considered both statically and dynamically. For purposes of mathematical treatment the case of a rectangular lake is taken. The theoretical results compare very favourably with the data obtained during a remarkable thunderstorm which swept over the lake on April 19, 1912. H. H. Ho.

823. *A Simple Theory of Ocean and Primitive Continent Formation.* E. Belot. (Comptes Rendus, 158. pp. 647-649, March 2, 1914.)—The author commences by remarking that upon the earth and on Mars the ocean surface is much greater in the southern hemisphere than in the other, while upon the moon the volcanic area is much more intense in the south than north, and he opines that this latter points to a similar inequality of distribution of the water originally on the moon. This unipolar condensation of water on the earth, moon, and Mars, may be easily explained if the relative translation of these three stars in the primitive nebula be assumed, the direction being that of the north part of their axes. This south-north translation had three principal effects: (1) The plastic terrestrial projectile became flattened in front and pointed behind. (2) The rotation, more retarded at the north than at the south pole, gave a twist to every relief in the sense of an easterly rotation of their southern parts. (8) At the exterior of the primitive terrestrial atmosphere, friction upon the nebula determined a general circulation in the sense N.-S. This circulation has been demonstrated and investigated by Boussinesq in the case of a drop of water falling through a liquid. About the south pole the atmospheric circulation caused cold vertical currents to descend, and after heating at the earth's surface to ascend hot. Consequently the temperature fell below 864° (the critical temperature of water), producing an abundant condensation of water under the pressures then prevailing. The water currents then set up proceeded to weather out the configuration of the primitive continents. This theory is illustrated by numerous examples of present continental conditions, which in the opinion of the author go to confirm his views. H. H. Ho.

824. *Seismological Evidence regarding the Earth's Interior.* B. Gutenberg. (Phys. Zeitschr. 14. pp. 1217-1218, Dec. 1, 1918. Extract.)—A discussion of seismometer observations taken at Göttingen. Only those records are chosen in which the epicentre was more than 80° below the horizon, and certain within 8° . The velocities and intensities of the direct and reflected waves are best accounted for by assuming the existence of a marked discontinuity 2900 km. below the surface as suspected by Wiechert (1907).

E. E. F.

825. *The Solar Constant of Radiation.* C. G. Abbot. (Washington Acad. Sci., Journ. 4. pp. 89-110, March 4, 1914. Address delivered before the Phil. Soc. of Washington, Jan. 8, 1914. Science, 89. pp. 385-348, March 6, 1914.)—Summarises work done on the subject and the results already made known in various of the author's earlier papers [Abstracts Nos. 795 (1912), 1606 (1913)]. The mean value from 690 measurements of the solar constant is given as 1.988 cal. per cm.² per min. Reference is made to recent experiments with sounding balloons and with which pyrheliometer measurements at altitudes as great as 40,000 m. are hoped for.

L. H. W.

826. *Summary of the Free Air Data obtained at Mount Weather for the Five Years, July 1, 1907, to June 30, 1912.* W. R. Blair. (Mount Weather Observatory, Bull. 6. pp. 111-194, 1914.)—During the period 1682 ascents were made on 1827 days. For the first 4 years only air pressure, temperature, and wind direction aloft were recorded. During the fifth year wind velocity and relative humidity were also measured. Details are given of the instruments used and of the method of calibration adopted. A method of increasing the sensitiveness of the hygrometer was found in separating the individual hairs to VOL. XVII.—A.—1914.

allow the air free access round each. Mean temperatures for levels 250 m. apart are given for each month. The temperature maximum at the surface was found in July, but at the 4.5-km. level in Aug. The question of how far the 5 years used may be regarded as typical years is discussed, and the effect of certain small sources of error considered. The observations are grouped according as they were made (1) in a high-pressure area, (2) in a low-pressure region, or (8) in the intermediate space between high and low. Groups (1) and (2) are also separated into four quadrants chosen relative to the direction of travel of the high- or low-pressure centre. The temperature gradient between 2.5 to 4 km. above M.S.L. is less variable from season to season and from quadrant to quadrant than that at lower levels. All levels considered, summer temperature gradients are the largest and winter temperature gradients the smallest in all the groups. The differences of temperature which occur on clear, calm days between Mount Weather and three valley stations in the neighbourhood are discussed at some length. The observations on wind velocity show a fairly rapid increase up to 1 km. above the earth's surface with all wind directions. The higher the wind velocity the further up this rapid increase extends. Considering the N. and W. components of the wind, the N. component on the whole varies little with altitude, while the W. component increases slightly with height, except for the first km. above the ground with east winds. The results are presented in 27 tables and many diagrams.

J. S. Dr.

827. *Oxygen in the Sun.* C. Runge and F. Paschen. (Phys. Zeitschr. 14. pp. 1267-1269, Dec. 15, 1918.)—The evidence for the presence of oxygen in the sun (Runge and Paschen, 1897) rests upon the observation of three red oxygen lines. That other lines are not present is not surprising, since the heads of series have an exceptionally high absorbing power. Geiger has observed (1912) the same lines in the spectrum of the iron arc. The authors have photographed the iron arc with a Rowland concave grating of 8 m. radius, and found all the lines described by Geiger, but the three lines corresponding to oxygen were only found in the neighbourhood of the anode, where the arc played about a drop of oxide. If the arc was obtained by putting a piece of iron on a carbon anode, no "oxygen" lines were obtained. The authors conclude that the solar lines 7772.01, 7774.21, and 7775.50 Å., are really due to oxygen.

E. E. F.

828. *Sun-spots and Meteor Swarms.* H. H. Turner. (Roy. Astronom. Soc., M.N. 74. pp. 82-109, Dec., 1918.)—In previous papers [Abstracts Nos. 89 (1914), 408 (1914)] various methods of analysis of the Wolf sun-spot numbers have been discussed, and the occurrence of *abrupt* changes in the series was suspected. The analytical method of detecting the discontinuities is described in detail. From the epochs of these disturbances a new theory is postulated involving the perturbation of the Leonid swarm of meteorites by Saturn.

C. P. B.

829. *Retrograde Satellite Orbits.* J. Jackson. (Roy. Astronom. Soc., M.N. 74. pp. 62-82, Dec., 1918.)—With the exception of Darwin's investigation of periodic orbits, all the analytical discussions of the problem of three bodies have only dealt with *direct* motions. The discovery of Phoebe and J VIII moving in retrograde orbits at great distances from their respective primaries rendered it important that a discussion of the peculiarities of retrograde satellite motion should be undertaken, and the results are given in full in the paper.

C. P. B.

830. *Astronomical Refraction*. C. Arnaud. (Comptes Rendus, 156. pp. 168-169, Jan. 19, 1914.)—Approximate formulæ have been given in a former note [*Ibid.* 156. pp. 1962-1964, June 30, 1918]. Further analysis is found to lead to a closer result, and the amended formulæ are given in form for logarithmic computation. C. P. B.

831. *Faint Companion to Capella*. R. Furuhielm. (Astronom. Nachr. No. 4715. Nature, 92. p. 724, Feb. 26, 1914. Abstract.)—Evidence is given of the existence of a 10.6 magnitude star as companion to Capella, situated at a relatively great distance from the primary (12' 8.8"). The detection was effected by comparisons of the proper motions of stars in the neighbourhood. C. P. B.

832. *Variations of Stellar Spectra and Proper Motions*. W. S. Adams. (Astrophys. Journ. 89. pp. 89-92, Jan., 1914. Contribution from the Mt. Wilson Solar Observatory, No. 78.)—One of the methods proposed by Kapteyn for the investigation of the question of the absorption of light in space is the comparison of the intensity at several different wave-lengths of the spectra of stars which are known to be near the earth with such as are very distant. The effect of general absorption or scattering increases towards shorter wave-lengths, and if such absorption is present in space we should expect the spectrum of the more distant star to fall off more rapidly in intensity towards the violet than would the spectrum of the nearer star. To investigate this a number of spectrograms of pairs of stars have been secured with the Cassegrain spectrograph at the Mount Wilson Observatory, care being taken to obtain approximate equality of density at the less refrangible end of the spectra. Also the spectral types of the two stars should be as similar as possible, and the photographs taken when the stars are at nearly the same zenith distance. Out of 20 pairs examined, 14 show a marked difference of intensity in the violet, and in every case the star of small proper motions is relatively faint. C. P. B.

833. *Kinetic Theory of Star-clusters*. J. H. Jeans. (Roy. Astronom. Soc., M.N. 74. pp. 109-112, Dec., 1918.)—An examination is made of the degree to which the results of the kinetic theory of gases may be applied to the analysis of the motions and distribution of the stars of a *star-cluster*. It is concluded that there is no possibility of a universe such as we know coming to a final steady state such as is found in the theory of gases. C. P. B.

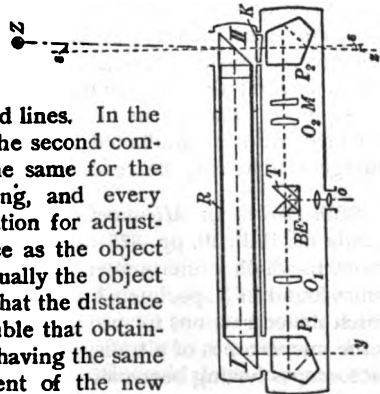
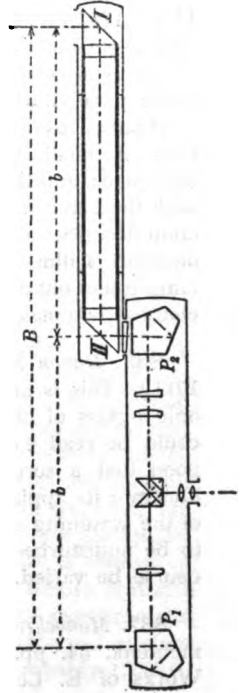
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834. *New Tachymeters with Absolute Correction.* R. Stützer. (Zeitschr. Instrumentenk. 84. pp. 1-11, Jan., and pp. 88-42, Feb., 1914.)—The military

surveying instruments described belong to the class for finding one side of a triangle from the base and two adjacent angles. The novel feature in their construction is that the system of reflecting prisms required for correcting the instrumental adjustments can be shifted into a second position to be utilised for providing a sufficiently long base-line during the process of actual measurement. An instrument of this type can be folded for transport, and when so folded is in the shape adapted for the preliminary observations for adjustment, all ready for beginning work on arrival. When the adjustments are made, the instrument can be extended by sliding the prism tube into the second position, and the measuring observations can then be undertaken. It is necessary for the prisms to have fixed deviation, either singly or in pairs, and hence only those systems are suitable which obey the ordinary laws of double or triple mirrors. In the case of the instruments dealt with in the first article, the base-line reduces to zero when the prisms are in the position for making adjustments, and the mark observed may be at any distance. Various forms of construction are described, differing in the nature of reflecting the system employed, which may be an ordinary prism with one reflecting surface, or a "rhombic" system with two nearly parallel reflecting surfaces, or there may be three reflecting surfaces. One form of construction (rhombic) is shown in the accompanying diagram. I and II are two reflecting prisms rigidly attached to the ends of the tube R, having their reflecting faces nearly parallel. The course of the rays is shown by the dotted lines. In the

case of the instruments dealt with in the second communication, the length of the base is the same for the operations of adjusting and measuring, and every measure must be preceded by an operation for adjustment upon a mark at the same distance as the object whose distance is to be measured. Usually the object itself will serve as mark. It is claimed that the distance can be measured with an accuracy double that obtainable with any of the older instruments having the same base and optical power. An instrument of the new type, say, for example, 60 cm. long when folded for transport, will when extended provide a base-line 1 m. long, and attain an accuracy equal to that of an old 2 m. instrument. A table of errors for a

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new instrument of the above size is given at the end of the paper. Various modes of construction are described : one form gives greater speed, another greater accuracy, yet a third form may be utilised alternatively with either view. While the instruments in the first article are more exclusively adapted to military purposes, those in the second might be applied to general purposes of topographic tachymetry.

A. E.

835. *Model Illustrating the Zeeman-effect.* P. Spies. (Phys. Zeitschr. 14. p. 1179, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—A horizontal shaft ends in a balanced crosspiece to the end of which a disc is attached, as well as another crosspiece capable of rotation in a plane parallel to that in which the first crosspiece rotates. The shaft is surrounded by a fixed disc connected to the movable disc by means of a belt. A small incandescent lamp is attached to the end of the second crosspiece, and this lamp traces out curves varying in shape and complexity with the ratio of diameters of the two discs. When these are as 2:1, the lamp describes a straight line. The effect of a magnetic field on a revolving electron is illustrated by making the ratio slightly different, whereupon the lamp traces out a star-shaped figure representing the actual movement of an electron in a magnetic field.

E. E. F.

836. *Davon Micro-telescope.* C. V. Boys. (Nature, 92. p. 595, Jan. 22, 1914.)—This is an interesting combination of microscope with a telescope object-glass of about $5\frac{1}{4}$ in. focus below the stage. Medium printed type could be read easily at a distance of 842 in., and the definition was so good that a series of artificial stars in tin-foil were without colour. To illustrate its application to natural history observation, a description is given of the watching of mice feeding 4 yards away, sufficiently distant for them to be undisturbed. The magnifying power used is about 42, but may of course be varied.

C. P. B.

837. *Monochromator.* M. Berek and F. Jentsch. (Zeitschr. Instrumentenk. 84. pp. 47-51, Feb., 1914. Communication from the Optical Works of E. Leitz.)—Describes a small monochromator giving intense light, specially suitable for microscope work. A total reflection prism is used to send the light from a small arc vertically downwards through a slit. The light then passes in succession through an achromatic collimator objective, a constant deviation prism, a second objective and a second slit; a lens beyond the slit renders the emergent light parallel or convergent as required. The prism is adjustable by means of a screw of fine pitch provided with a graduated head from which the wave-length of the emergent light may be read.

A. W.

838. *Errors in Micrometer Microscopes.* A. W. Gray. (Bureau of Standards, Bull. 10. pp. 875-890, 1914.)—Reviews the nature of the possible errors to which a micrometer microscope is liable and gives a table of the errors found in 5 specimen instruments. The author describes a method by which the corrections for progressive and periodic errors in such instruments as the microscopes of a transverse comparator may be made very readily, the microscopes having been calibrated once for all. The results of each calibration are embodied in a table giving directly for each tenth of a turn the total correction to be added to the reading of the micrometer. The corrections for the hundredths are obtained by interpolation. All corrections are given in terms of the microscope division as unit, so that they may be applied directly

and multiplication by the reduction factor be deferred until the end. The specimen calibration described was made by removing the ocular of the microscope under examination and measuring the displacements of a spider line on its screw by means of an auxiliary micrometer microscope. Three sets of measurements were made: (i) the distance travelled by the spider lines as the screw under investigation was advanced 5 whole turns; (ii) the distance travelled during each single turn; and (iii) the distance travelled during each fifth of a turn. This was done (with some exceptions noted in the paper) for the whole length of the screw, and the results plotted for each set of observations. These three sets of curves were then made mutually consistent, and the smoothed curves thus obtained gave (after reductions (i) to the units noted above and (ii) in order to bring the points of smallest correction as near as possible to the centre of the screw) the differences to be entered in the table. This was done for each of the two microscopes composing the comparator and exceedingly consistent results were obtainable by correcting from the tables drawn up in this manner.

J. W. T. W.

839. Preparation of Eye-preserving Glass for Spectacles. W. Crookes. (Roy. Soc., Phil. Trans. 218, pp. 1-25, Feb. 5, 1914.)—The paper describes experiments carried out in connection with the Glass Workers' Cataract Committee of the Royal Society, since March, 1909, on the effect of adding various metallic oxides and earths to the constituents of glass in order to cut off the invisible rays at the ends of the spectrum. The author had the assistance of H. Powell, of the Whitefriars Glass Works, who prepared several pots of coloured glass from formulæ on a larger scale than was possible in the laboratory. The main object is to prepare a spectacle glass to prevent the heat rays from highly heated molten glass from damaging the eyes of workmen, but the work also involves an investigation of the screening properties of glass plates for ultra-violet and for luminous light. By way of preliminary, a number of photographs of spectra of molten bottle-glass were taken at Messrs. Nuttall's Glass Bottle Works by means of a quartz spectrograph with panchromatic films. The bottle-glass was composed of silica, sodium sulphate, and calcium carbonate or sulphate, and the temperature in the tank was probably 1200° C. to 1500° C. The photographed spectrum is found to extend progressively into the ultra-violet as length of exposure increases, reaching to $\lambda 4520$ with 20 minutes' exposure, and to $\lambda 8845$ with 180 mins. Thus it is seen that, with an exposure of 8 hours to the greatest heat, the strength of impression does not extend far into the ultra-violet. The ordinary limit of visibility is generally taken to lie between $\lambda 8900$ and $\lambda 7600$.

The heat rays from the molten glass are very strong. Since the infra-red rays are present in far greater abundance than the ultra-violet, the inference is that it is to the heat rays rather than to the ultra-violet rays that glass-workers' cataract is to be ascribed. It is, however, certain that exposure to excess of ultra-violet light also injuriously affects the eye. That the ultra-violet rays act on the deeper-seated portion of the eye is shown by the intense fluorescence of the crystalline lens induced by these rays. The cornea is opaque to rays shorter than $\lambda 8200$, the crystalline lens to rays shorter than $\lambda 8500$, and rays of longer wave-length than $\lambda 8600$ reach the retina. The author notes that, with a quartz spectroscope, he could formerly see the line M, $\lambda 8727$, and it may be taken that the ultra-violet rays to be cut off as injurious are those of wave-length shorter than, say, $\lambda 8700$. Besides the invisible rays at each end of the spectrum, the purely luminous rays if present in abnormal intensity are found to damage the eye. Tests made

to see if X-rays could be detected confirm Burch's conclusion that X-rays are not emitted by the highly incandescent molten glass. To be generally useful it is desirable to obtain a glass opaque to wave-lengths longer than about $\lambda 7200$ and shorter than about $\lambda 8550$. To solve the problem of the best material for protective spectacles, various glasses were made in the laboratory, using as basis a clear soda flux, not containing lead (supplied from Whitefriars Glass Works in a crushed state), and adding to it quantities of pure metallic oxides and earths as colouring or absorbing media. An early paper by Faraday "On the Manufacture of Glass for Optical Purposes: Bakerian Lecture, 1829" (Roy. Soc., Phil. Trans. p. 1, 1830) was found useful. At first, single metals were tried in varying quantities. For testing purposes each specimen of glass is cut and polished into a plate 2 mm. thick. The plate so prepared is first tested in the spectrum apparatus to ascertain the upper limit of transmission of the ultra-violet rays. It is next put into a special form of radiometer balance to see the percentage of heat cut off, then tested in Chapman Jones's opacity balance (Photographic Journ. 28, p. 99) to see the percentage of luminous rays transmitted, and finally the colour is registered in a Lovibond's tintometer. In making the heat tests, Melloni's thermopile was found to respond to orange and red rays as well as infra-red, and therefore a piece of biotite or black mica was used in conjunction with it. Biotite resembles dark smoky quartz in transmitting nearly all the heat, whilst cutting off 80 or 90 per cent. of the light, and it is easier to work with. A large number of metallic elements were tested in this manner, many of which proved unsuitable. The following were selected as most promising for further experiment in combination, and details are given regarding their behaviour: Cerium, chromium, cobalt, copper, iron, lead, manganese, neodymium, nickel, praseodymium, uranium. Curiously enough, a glass in which black biotite was used as an ingredient shows the opposite effect to what might be expected, being almost opaque to the heat rays. It allows 80 per cent. of incident light to pass through, and is opaque to ultra-violet beyond $\lambda 8610$.

Over 800 tinted glasses of known composition have been made and tested. The ideal glass that will fulfil the three conditions of perfect opacity to heat, perfect opacity to ultra-violet, and transparency to visible rays, has yet to be discovered, but it is now possible to choose a glass to fulfil any one of the three conditions perfectly and the other two fairly well. For the desired object, it is not an unmixed advantage for the glass to be quite clear. A tinted glass combining good obstruction to the heat radiation and ultra-violet is the best to aim for. Grey or neutral tints are the pleasantest to wear, as they do not alter the colours of objects. The outcome of the investigation is a selected list of 21 glasses possessing valuable qualities in respect of athermancy, adiactinity, and transparency. They include specimens suitable for spectacles for all requirements, and are tabulated in four classes, designed respectively for: I. Absorption of heat rays, II. Absorption of ultra-violet rays, III. Transmission of luminous rays, IV. Reduction of glare. Under the last head come 6 glasses described as best for general use in bright sunshine, on snow, etc. They cut off from 80 to 60 per cent. of the visible light, and also have the advantage of cutting off practically all the ultra-violet, and a considerable amount of the heat radiation.

A. E.

840. *Selective Reflection of Infra-red Light by Solutions.* A. K. Ångström. (Phys. Rev. 8. Ser. 2 pp. 47-55, Jan., 1914).—The max. selective reflection from water at wave-length 8.20μ is shifted to longer wave-lengths by the addition of the strongly hydrated salts CaCl_2 and SrCl_2 , but no appreciable effect is observed with BaCl_2 . VOL. XVII.—A.—1914.

ciable shift was produced by adding NaCl, Na₂SO₄, KNO₃, or CuSO₄. [If this statement is correct it seems probable that figs. 1 and 8 have become interchanged in the printed paper.] A similar shift is produced by the addition of NaOH and KOH. Strong sulphuric acid gives a maximum of longer wave-length than water; aqueous sulphuric acid gives a maximum at intermediate wave-length, but of diminished intensity.

T. M. L.

841. *Reflection of Long-waved Heat Rays by Rough Surfaces and Gratings.* T. J. Meyer. (Deutsch. Phys. Gesell., Verh. 16. 8. pp. 126-141, Feb. 15, 1914. Extract of Dissertation, Berlin.)—Measurements were made with plates of silver and nickel roughened with emery paper for wave-lengths varying from 0.6μ up to about 800μ . Other plates were roughened by means of a sand blast. The results are tabulated and graphed for various angles of incidence. In general an increased reflecting power was observed with increased wave-length. The gratings employed had rulings of depths varying from about 20μ to 80μ , width of rulings from 60μ to 80μ , and distance between rulings from 50μ to 400μ . Polarised light was used in the grating experiments, the wave-lengths ranging from 52μ to 818μ . With a given grating there is in general, as with the roughened surfaces, an increased reflecting power with increased wave-length, but in a few cases a slight diminution in reflecting power was observed when the wave-length of the incident light was altered from 52μ to 110μ . An explanation of this is to be found in the fact that with constant wave-length of the incident light and with constant depth of ruling the reflecting power increases with the distance between the rulings. With constant wave-length and grating distance the reflecting power is constant, or very nearly so, as the depth of the rulings is increased. Experiments were also made with metal wire gratings. [See also Abstract No. 1855 (1901).]

A. W.

842. *Ultra-violet Photometry.* J. Elster and H. Geitel. (Phys. Zeitschr. 15. pp. 1-8, Jan. 1, 1914.)—A lamp has been designed for obtaining special radiations desired for comparison lights in the photometry of sunlight in the ultra-violet. Sketches are given showing the arrangement of the electrodes, for which zinc and cadmium have been utilised in various forms. Comparison measurements are given showing the constancy of the illumination compared with the Heraeus quartz mercury lamp.

C. P. B.

843. *Quantitative Spectrophotography.* H. Ewest. (Photographic Journ. 54. pp. 99-107, Feb., 1914.)—Photographic photometry is based upon the quantitative comparison of the densities resulting from two exposures, and deducing therefrom the relation between the exposures themselves. The density of an exposed and developed plate depends upon a number of factors: λ the wave-length of the light acting, its intensity i , the time of the exposure t , the properties of the developer e , and the character of the plate p , hence $S = f(\lambda, i, t, e, p)$. λ can be easily kept the same by special decomposition, t can be measured very exactly, the constancy of i depends on the light source selected; e depends on the temperature, character, and composition of the developer and the length of time it is acting on the plate; p is a function of the mode of preparation of the emulsion, the age of the plate, its moisture content, and its sensitiveness. If the influences of λ , e , and p is eliminated $S = \phi(i, t)$ or $i = \psi(t, S)$ and for equal values of S , $i = \chi(t)$, so that $i_1/i_2 = \chi(t_1)/\chi(t_2)$. The various methods may be divided into two classes: firstly, those in which a definite assumption is made concerning the function

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$x(t)$, and secondly, those in which t_1 is made equal to t_2 , one of the light intensities being reduced in a measurable manner until $S_1 = S_2$, and therefore $i_1 = i_2$. By adopting the latter procedure the relation between the original light intensities can be calculated without making assumptions concerning the function ϕ . Methods of weakening a light intensity in a known manner are mentioned. Then methods with constant " t " are considered.

The author's apparatus, which is not intended for work of high accuracy, but primarily to test the method, is described in detail. An investigation of the errors inherent in the apparatus is made and the various possible sources of error in work of this kind are discussed in detail. In the original paper, of which this is an abstract, there are a number of curves showing the results given by the author's method in comparison with direct spectrophotometry of the same solutions. These are in very fair agreement. The suggestions for perfecting the method are:—The use of a constant light source; accurate construction; the use of a microphotometer for determining the positions of equal density on the spectrograms; coating the wedge on a quartz plate for work in the ultra-violet or the use of a stripped wedge. The use of a compensating filter adjusted to the plate to get smoother curves would be just as feasible as in Mees's method, but it is proposed instead to use a slot, in front of the wedge and plate, whose width is varied in accordance with the sensitiveness of the plate at different parts of the spectrum. A. E. G.

844. Effect of Temperature on a Rowland Grating Apparatus. L. Grebe. (Zeitschr. wiss. Phot. 18, pp. 264-268, Feb., 1914.)—Discusses the effect of variations of temperature of the room containing a concave-grating apparatus. The relative expansion and the massiveness of the grating and the rest of the apparatus are considered. The conclusion is reached that only if the temperature variations do not exceed 1 deg. C. are they without prejudicial effect on very accurate wave-length measurements. A. W.

845. Optical Anisotropy of Liquid Crystals. D. Vorländer. (Phys. Zeitschr. 15, pp. 141-145, Feb. 1, 1914.)—So far as the investigation has gone (the author has examined liquid-crystals of 900 substances, including 400 new cases) the liquid crystals of all organic compounds are optically uniaxial in their primary forms; this is associated with the "linear" form of a long chain-like molecule. The biaxial character recognised by Lehmann in *p*-azoxyphenetol is attributed to pleochroism and circular polarisation, consequent upon the addition of colophony or sugar, in liquid crystals which are still uniaxial. Again, in opposition to Wallerant, who has described biaxial plates of *p*-azoxyanisol, the author states that on cooling either thick or thin layers of the amorphous melt between a microscope slide and coverglass the pure compound gives no optic axial figures, nor can these be developed by the usual methods of mechanical disturbance; interference figures can be developed in presence of impurities, but these are always uniaxial.

The author states that optically-active liquid crystals are invariably negative in their double refraction, and that all other liquid crystals are positive. Some substances can, however, exist in both forms, *i.e.* as inactive, positive, uniaxial, liquid-crystals, or as optically active, negative, uniaxial, liquid-crystals. The optical activity of liquid-crystals is always a consequence of molecular asymmetry. T. M. L.

846. Constancy of the Velocity of Light. W. de Sitter. (Phys. Zeitschr. 14, p. 1267, Dec. 15, 1918.)—A reply to Freundlich [Abstract No. 66 (1914)]
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The velocity of light may be put $= c + Ku$, where u is the velocity of the source. Between $K=0$ (Lorentz) and $K=1$ (Ritz) the choice is easy, and even Freundlich admits that the latter value is inconsistent with observations. Whether K is a measurable fraction remains to be decided. From observations on β Aurigæ the value for K is about 0.002. Against Freundlich's plea of a preference of the line of apsides for the direction of the line of sight the author brings to bear another statistical fact which is better established, viz. that spectroscopic binaries of short period, and hence large u , have smaller eccentricities than those of long period. If the velocity of light depended upon that of the source, the contrary would have to be expected. E. E. F.

847. The Sagnac-effect. Existence of the Ether. H. Witte. (Deutsch. Phys. Gesell., Verh. 16. 8. pp. 142-150, Feb. 15, 1914.)—A criticism of the conclusions deduced by Sagnac from his experiments with a rotating interferometer [see Abstracts Nos. 65 and 216 (1914)]. Witte concludes that the effect observed by Sagnac does not prove the existence of the ether.

A. W.

848. Optical Constants of Potassium and Sodium. B. Meese. (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 4. pp. 580-588, 1918.)—Describes experiments with mirrors of potassium and sodium and gives the values obtained for their optical constants. These are in good agreement with those of R. W. and R. C. Duncan [Abstract No. 1269 (1918)]. E. H. B.

849. Ponderomotive Couples of a Light Source and the Principle of Action and Reaction. K. Schaposchnikov. (Ann. d. Physik, 48. 8. pp. 478-480, Feb. 10, 1914.)—Points out that Abraham's theory of ponderomotive actions in electromagnetic fields is unable to explain the above twisting phenomena.

E. H. B.

850. Theory of Light Absorption in the Atmosphere. M. Milankovitch. (Ann. d. Physik, 48. 4. pp. 623-638, Feb. 27, 1914.)—A mathematical treatment on somewhat similar lines to Poynting's work on the "Surface Temperatures of Planets" [Abstract No. 898 (1908)], but conforming more closely, in the the author's opinion, to actual conditions.

L. H. W.

851. The Extraordinary Ray Resulting from the Internal Reflection of an Extraordinary Ray at the Surface of an Uniaxial Crystal. J. Walker. (Phys. Soc., Proc. 25. pp. 298-299, June, 1918.)

852. Rotatory Polarisation in Liquids. E. T. Paris and A. W. Porter. (Phil. Mag. 27. pp. 91-95, Jan., 1914.)—In order to determine whether polarised light has a directive influence on the molecules of a sugar solution, measurements of rotatory power for the green mercury line Hg 5461 were made with sparks lasting not more than 8×10^{-6} sec. and a steady arc. The values for the spark were less by about 1 part in 18,000 on readings of about 500° , but this was regarded as within the limits of experimental error.

T. M. L.

853. Rotatory Power in Biaxial Crystals. F. Wallerant. (Comptes Rendus, 158. pp. 91-98, Jan. 12, 1914.)—Measurements have been made of the rotation produced in light of different colours travelling along one optic axis of a biaxial crystal of antimony ammonium tartrate. The values obtained were:—

$\lambda =$	620	570	586	491	
$\alpha =$	$+189^\circ$	$+168^\circ$	$+185^\circ$	$+249^\circ$	T. M. L.
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854. Measurement of Small Displacements of Spectrum Lines. J. Evershed. (Kodaikanal Observatory, Bull. 82. Nature, 92, p. 540, Jan. 8, 1914. Abstract.)—A positive copy of the plate to be measured is made, and then placed in reverse position in contact with the original, film to film. Provision is made for moving one plate relatively to the other by any required amount controlled by a micrometer screw. The measurements are made by estimating when the positive image of a given line exactly overlaps its negative counterpart, the sensitiveness depending on the ability of the eye to recognise very slight differences of density. The method is illustrated by actual results obtained in the measurement of plates showing the solar rotation. C. P. B.

855. Wave-length Standards. H. Viefhaus. (Zeitschr. wiss. Phot. 18. pp. 209-284, and pp. 245-264, Feb., 1914.)—Describes and gives results of the measurement of a large number of tertiary wave-length standards in the arc spectrum of iron, ranging from $\lambda 2987$ to $\lambda 4118$. Six tables of lines are given, the mean errors of measurement of the wave-lengths varying progressively from the first, which contains lines for which the mean error does not exceed 0.001 I.Å. unit, to the last, which gives wave-lengths of lines for which the mean error is greater than 0.008 I.Å. unit. An additional table gives all the lines measured and compares the results with those of Burns [Abstract No. 1486 (1913)]. A. W.

856. Secondary Wave-length Standards in Iron Arc Spectrum. H. Kayser, J. S. Ames, H. Buisson, and F. Paschen. (Astrophys. Journ. 89. pp. 98-94, Jan., 1914.)—Experience having shown that many of the arc lines of iron are not suited for fundamental measurements of wave-length, the method of selection and conditions for producing the arc were agreed to by an international committee during the Solar Union meeting at Bonn in Aug., 1918. It was resolved: (1) That the length of the arc should be 6 mm. (2) For wave-lengths greater than $\lambda 4000$ the current should be 6 amps., and 4 amps. or less for shorter wave-lengths. (3) Continuous current should be used, at 220 volts, with 7-mm. diam. as electrodes. The arc should be vertical, the positive electrode being the upper one. (4) The middle part of the arc, in its axis, for a length of 2 mm., should be used. (5) Only the lines belonging to the groups *a*, *b*, *c*, *d* of the Mount Wilson classification should be used. The committee recommends that many more secondary standards be determined, to allow of more convenient interpolation. A list of the adopted secondary standards of iron and nickel is included in the paper. C. P. B.

857. Arc Spectrum of Iron. K. Burns. (Lick Observatory, Bull. No. 247. Zeitschr. wiss. Phot. 18. pp. 235-244, Feb., 1914.)—Using a 21.5-ft. Rowland concave grating mounted in the Abney style, with grating and camera fixed, slit moving round a circular arc having a radius equal to half the radius of curvature of the grating, the arc spectrum of iron has been photographed from $\lambda 8206$ to $\lambda 7800$. The results are presented as a contribution to the International Standards of Wave-lengths, and comparisons are given with the results of other workers on the same spectrum. C. P. B.

858. Spectrum of Calcium Arc in Vacuo. H. Crew and G. V. McCauley. (Astrophys. Journ. 89. pp. 29-38, Jan., 1914.)—A new series of spectra of the calcium arc *in vacuo* have been investigated for the determination of the wave-lengths on the international system, it being found that the lines obtained at low pressure (about 1 cm.) were much better defined than at
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ordinary atmospheric pressure. The wave-lengths tabulated extend from $\lambda 2103.289$ to $\lambda 7826.099$. Eleven new lines were found, eight of these belonging to the first subordinate series of main triplets. C. P. B.

859. *Resonance and Selective Superficial Diffusion of Sodium Vapour for D-light.* L. Dunoyer. (Journ de Physique, 4. Ser. 5. pp. 17-84, Jan., 1914.)—The light from a carbon arc gives rise in sufficiently pure Na-vapour to an orange fluorescence [Abstract No. 1840 (1912)]. The light from that part of the arc near the negative carbon excites this fluorescence much more strongly than that from the positive crater. A bright surface glow may be obtained where the exciting light enters the vapour. This surface effect was studied in detail. Different parts of the arc flame differ much in their power to produce this superficial resonance. The edge of the flame is particularly rich in exciting rays. Putting salt into the positive crater increased the yellow colour of the arc flame, but the surface resonance was less intense than without it. The effect is exhibited best when the temperature of the bulb containing the Na-vapour is raised to about 250° or 800° . Certain experiments tend to show that the light which is effective in producing the surface resonance is confined to the central parts of the sodium D_1 and D_2 lines. A Savart polariscope was used to investigate the light emitted by the surface resonance, but no trace of polarisation could be observed whether the incident light was polarised or not. The addition of hydrogen to the Na-vapour diminishes the intensity of the surface resonance without altering its character, though at first it appears to have the effect of increasing the intensity of the volume resonance. In the latter part of the paper the resonance phenomena of the vapours of Na and Hg are compared [see Abstract No. 1182 (1912)]. A. W.

860. *Variability of Absorption Spectra.* G. H. Livens. (Phys. Zeitschr. 14. pp. 1271-1278, Dec. 15, 1913.)—It appears almost certain that only a small proportion of the atoms, say, of Na-vapour, are at any given instant effective in producing an absorption line, perhaps one in a thousand. The absorbing action only takes place during ionisation or recombination. That being so, it is clear why heat increases the absorbing power of a given amount of vapour, the ionic processes being livelier. The observation that heat has the same effect as an increase of density is thus qualitatively explained. [See also Abstract No. 227 (1914).] E. E. F.

861. *New Type of Absorption Spectra.* J. Koenigsberger and K. Vogt. (Phys. Zeitschr. 14. pp. 1269-1271, Dec. 15, 1913.)—The vapour of "tetrazine" $C_2N_4H_2$, discovered by Curtius, shows very peculiar absorption lines. The spectrum resembles the absorption line spectrum of metallic series, such as has not hitherto been found in compounds. The lines show no discoverable Zeeman-effect; nor do they show the magnetic double refraction characteristic of band spectra. They do not form a spectrum series. Certain lines, though sharp, show a continuous background (also found in some metallic lines). On heating the vapour to 85° a bright line appears just beside each of the absorption lines, even when the pressure is as low as 17 mm. Hg. These bright lines are not true emission lines, but probably due to some kind of "directed resonance" such as is assumed according to Huyghens' explanation of the rectilinear propagation of light. E. E. F.

862. *Quantitative Investigation of the Absorption Spectra of Solutions by Means of the Radiomicrometer.* H. C. Jones and J. S. Guy. (Ann. d. VOL. XVII.—A.—1914.

Physik, 48. 4. pp. 555-604, Feb. 27, 1914.)—An account of investigations, the results of which have been published previously [see Abstracts Nos. 880 (1907), 68, 1276 (1918)], and dealing especially with the absorption spectra of solutions of salts of neodymium, praseodymium, nickel, and cobalt. T. S. P.

863. *Line Spectrum of Nitrogen in a Geissler Tube.* C. Porlezza. (Gazzetta Soc. Chim. Ital. 48. ii. pp. 699-708, 1918.)—Gives the results of measurements of the wave-lengths of the lines of this spectrum, many of which have hitherto been ascertained only approximately. L. H. W.

864. *Spectrum of Nitrogen in Magnetic Field.* H. Deslandres and L. d'Azambuja. (Comptes Rendus, 158. pp. 158-159, Jan. 19, 1914.)—Following on the recognition that when a light source giving band spectra is placed in a magnetic field the rays of the same arithmetic series are all displaced in the same sense or are divided in the same manner, with any dissymmetry in the same sense, the authors proceed to examine in detail the influence of the magnetic field on the second group of nitrogen bands. For some time after the discovery of the Zeeman-effect it was thought that *band* spectra were exempt from the division shown by *line* spectra, but this was apparently due to insufficient magnetic power, as it has recently been shown by Fortrat [Abstract No. 668 (1914)] that when a field of 40,000 to 50,000 gauss is employed certain displacements are detected, but there is no division and no polarisation. In the present author's experiments a field of 85,000 gauss has been used, in conjunction with a very powerful spectrograph giving a dispersion of 1.40 mm. to 1 Å. at $\lambda 400$, and the observations have been made both parallel and perpendicular to the field. Sketches are given showing the displacements found on the photographs. C. P. B.

865. *Band Spectra in Magnetic Field.* R. Fortrat. (Comptes Rendus, 158. pp. 884-885, Feb. 2, 1914.)—Referring to the paper by Deslandres and d'Azambuja [see preceding Abstract], it is pointed out that they do not appear to have followed out the effects produced by variations of field strength. By doing this a measure of the *sensibility* of the different rays can be obtained. If n is the natural separation of a group of rays of a doublet or triplet, δn its diminution by field H , the value $n \cdot \delta n/H^2$ is constant for the same grouping, and may be taken as a measure of the sensibility to the effect of the field. C. P. B.

866. *Zeeman-effect and Quantum Theory of Spectral Series.* K. F. Herzfeld. (Phys. Zeitschr. 15. pp. 198-198, Feb. 15, 1914.)—The magnitude of the Zeeman-effect is calculated in accordance with the quantum theories of spectral series of Hasenöhl and Bohr [Abstracts Nos. 205, 1980 (1918)]. On both theories the electron acquires in the presence of a magnetic field a precession motion. Many suppositions are possible in both theories. The simplest and most plausible is that the quantum laws hold good with regard to a plane which takes part in the precession motion. Both theories then give normal triplets. Further, Bohr's theory gives a separation and broadening proportional to the square of the field strength, and it follows also that the radius of the orbit of an electron is large with respect to that of the atom. A. W.

867. *Zeeman-effect in Satellites of Mercury Lines.* H. Nagaoka and T. Takamine. (Phil. Mag. 27. pp. 838-848, Feb., 1914.)—A brief review is first given of earlier work on this subject. The object of the research dealt
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with in the latter part of the paper was to follow the whole course of the change in the lines from weak to strong fields, and to show that the separation of the lines is not generally subject to the law of linear proportionality to the magnetic force, including the singular case, in which change of wavelength is proportional to the square of the magnetic field, as one type of separation. It is further shown how the satellites gradually tend to approach asymptotically the branches of the principal line when the field is sufficiently increased. An échelon spectroscope was used, combined with either a Lummer-Gehrcke plate or, preferably, a sliding Fabry-Perot interferometer for eliminating false lines. A brief account of the research has previously been given [Abstract No. 1958 (1918)]. More detail is now given and typical photographs are reproduced. A. W.

868. Secondary Rays due to Hard X-rays. J. Laub. (Phys. Zeitschr. 14, pp. 1209-1210, Dec. 1, 1918).—Announces the discovery of a harder homogeneous fluorescent X-radiation in Pt and Zn, with absorption coefficients 7.2 and 5.4 cm.² gm.⁻¹ respectively. Sulphur and carbon emit a very hard homogeneous radiation with absorption coefficients 0.21 and 0.87. The author holds that Pt and Zn emit a series of fluorescent "Röntgen lines," whereas carbon and sulphur emit only one sharp line each. This sharp and hard radiation belongs to a new class of secondary rays. It has not been observed in the case of bodies of higher atomic weight, probably because it is then too penetrating. E. E. F.

869. New Verification of the Laws of Transparence of Matter to Röntgen Rays in the Special Case of Complex Minerals. L. Benoit and H. Copaux. (Comptes Rendus, 158, pp. 559-561, Feb. 28, 1914).—In order to verify the laws of transparence of matter to complex minerals the following three mineral salts are used: ferrocyanide of potassium $[\text{Fe}(\text{CN})_6]\text{K}_3$, cobaltic chloropentamine $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$, and silico-molybdate of potassium $[\text{Si}(\text{Mo}_2\text{O}_7)_3]\text{K}_4\text{H}_4 + 16\text{H}_2\text{O}$. The equivalents of transparence are calculated according to the formula $M/E = \Sigma m/e$ in which M , m , etc., represent the masses of the component elements and E , e , etc., the corresponding equivalents of transparency for the quality of Röntgen rays employed. The equivalents determined experimentally, *i.e.* fluoroscopically or radiographically, are compared with these theoretical results. It is found that the numbers obtained are in good agreement, so that it can be safely asserted that the laws of transparence, in particular the additive law, hold true for complex mineral as for other substances to the degree of approximation of the photometric measurements—that is, to 5% or less. A. E. G.

870. Debye-effect. M. v. Laue and J. S. van der Lingen. (Phys. Zeitschr. 15, pp. 75-77, Jan. 15, 1914).—According to the theory of P. Debye the temperature influence on the interference phenomena with Röntgen rays decreases the brightness of the interference spots with higher temperatures, those spots nearest the incident one being, however, in general less affected than the more distant ones. The present work aims at a qualitative proof of this theoretical deduction. The experimental arrangements are shown generally and in detail by diagrams. The result of the investigation is that, at any rate qualitatively, the theory of Debye rightly expresses the influence of temperature. [See Abstract No. 1668 (1913).] E. H. B.

871. Optics of Space Lattices. M. v. Laue. (Phys. Zeitschr. 14, pp. 1040-1041, Nov. 1, 1918).—Shows that the maxima calculated by VOL. XVII.—A.—1914.

Ornstein's theory [Abstract No. 1666 (1918)] agree in every respect with those calculated from his own theory. Maintains that Ornstein does not clearly distinguish between "coherence" and "interference with difference of path of whole wave-lengths."

E. E. F.

872. Interference of X-rays. W. Friedrich. (Phys. Zeitschr. 14. pp. 1079-1084; Discussion, pp. 1084-1087, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—An account of the discovery of X-ray interference, together with subsequent results obtained by Bragg, Moseley and Darwin, Herweg, and others. Points out the importance of determining independently the wave-length of X-rays and the grating constant. This is easier since it is possible to obtain homogeneous X-rays. In the discussion, v. Kowalski raised the question as to whether the spiral structure of quartz could be imitated by building up plates of mica. Laue replied that it would not be possible to space the mica plates sufficiently evenly. Lehmann mentioned that the failure to obtain these interference patterns in liquid crystals was due to the fact that the molecules of such crystals are not arranged in space lattices, but in rings round certain axes. E. E. F.

873. Interference of X-rays. E. Wagner and R. Glocker. (Phys. Zeitschr. 14. pp. 1282-1287, Dec. 1, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—A beam of X-rays is reflected at an angle of about 9° from one of the lattice surfaces of a crystal of rock-salt. A monochromatic beam corresponding to one of the interference patches is reflected similarly by a second crystal. The interference pattern thus obtained is a very simple one, due to a single wave-length or low multiples of it.

E. E. F.

874. Optics of Space Lattices. L. S. Ornstein. (Phys. Zeitschr. 14. pp. 1229-1281, Dec. 1, 1918.)—Shows that if X-rays consist of a continuous spectrum, a crystal acts as an harmonic analyser, isolating a definite wave-length. Maintains that Laue's mode of calculation leads us to regard the X-ray beam as having such a continuous spectrum. M. v. Laue. (Ibid. pp. 1286-1287, Dec. 15, 1918.)—Laue disagrees with Ornstein's contention that if a plane sine wave is reflected by a surface net containing N illuminated particles, the intensity of the reflected ray is proportional to N^2 . It is proportional to N . That the intensity of any interference patch is proportional to Nn (where n is the number of plane layers) can be derived from Laue's original equations.

E. E. F.

875. Influence of Temperature in X-ray Interference. M. v. Laue. (Ann. d. Physik, 42. 6. pp. 1561-1571, Dec. 28, 1918.)—From Debye's investigation of heat motion in solids, the author derives the conclusion that temperature has no appreciable effect on X-ray interference patterns, and that the peculiarities of the patterns previously attributed to heat motion are due to irregularities of structure.

E. E. F.

876. Analysis of Crystals by the X-ray Spectrometer. W. L. Bragg. (Roy. Soc., Proc. Ser. A. 89. pp. 468-489, Feb. 2, 1914.)—In a former paper [Abstract No. 87 (1914)] the structures of NaCl, KCl, KBr, and KI were studied from evidence based on the Laue photographs obtained when X-rays are transmitted through the various crystals. The X-ray spectrometer, which was devised by W. H. Bragg for the purpose of studying the reflection of X-rays by crystals, affords a much more powerful method of research into the structure of the crystal [see Abstract No. 86 (1914)]. The X-ray spectro-

meter employs a monochromatic radiation and the faces of the crystal are examined in detail, one by one, by observing the angle (θ) at which the particular radiation is reflected. This gives the distance d from plane to plane parallel to the faces [$n\lambda = 2d \sin \theta$]. Moreover, if the successive planes of atoms are of identical composition, the results of the examination show this by the gradual decrease in the intensity of reflection corresponding to the various orders. On the other hand, if successive planes differ in composition the nature of the variation can be deduced from the relative intensities of the reflection in the different orders. Thus in the case of reflection from the 1.1.1. planes of NaCl the second order spectrum is about five times as strong as the first, while the third order spectrum is missing and the fourth order moderately strong. This is simply explained by assuming that the planes contain alternately either all Cl-atoms or all light Na-atoms. The first order spectrum corresponds to the spacing $d_{(111)}$ of Cl to Cl planes. The reflection corresponding to this spacing is spoilt, however, by the interposition of the lighter Na-atoms, exactly intermediate with the Cl ones. The effect of this is to weaken all the odd spectra in comparison with the even. If the Na planes were so weak as to be non-effective, the odd spectra would be of normal strength. If they become as effective reflecting planes as the Cl planes, the odd spectra would disappear entirely. What is actually the case represents an intermediate state of affairs. This justifies the structure given in the author's former paper.

More complicated crystals are next examined, proceeding on the above general lines. The angles of reflection and the intensities of the various orders are measured with Pd X-rays falling on the various faces of the crystals. The angles of reflection give the positions of the heavier atoms in the crystal. Further, on the assumption that an atom diffracts the rays to an extent proportional to its atomic weight, the positions of the other atoms are deduced from the observed relative intensities of the various orders. This assumption is verified by an interesting series of measurements with NaNO_3 , $\text{CaMg}(\text{CO}_3)_2$, CaCO_3 , MnCO_3 , and FeCO_3 , in which series the weight of the metal gradually increases towards that of the group (CO_3) .

The results show that in zinc blende the Zn atoms lie on a face-centred lattice as do the Cl-atoms in NaCl. The S-atoms occupy positions at the centres of four of the eight elementary cubes inside this lattice. In fluorspar, CaF_2 , the arrangement is the same as for S zinc blende except that the S-atoms are at the centres of all the elementary cubes of the space lattice. In iron pyrites, FeS_2 , the Fe-atoms are again arranged as in a face-centred lattice, but the S-atoms are no longer at the centres of the figure of the structure, but on the diagonals of the elementary cubes of the lattice at a distance from the Fe-atoms $4/5$ of the length of the diagonal. The structure of calcite and a few other crystals are also investigated in the paper. E. M.

877. *X-ray Spectra*. J. Herweg. (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 78-78, Jan. 18, 1914.)—The author has investigated antikathodes of platinum and tungsten, the pencil of X-rays used emerging at a glancing angle so as to give the effect of a line source [Abstract No. 1831 (1913)]. Selenite was used as crystal, and the reflected rays were registered on a photographic plate. Five lines were found for Pt at relative angles very nearly the same as those found by Moseley [Abstract No. 467 (1914)]. The spectrum of tungsten was found to contain two lines with almost the same wave-lengths as two of the lines of Pt but with a different relative intensity.

E. M.

878. X-ray Spectra. M. de Broglie. (Comptes Rendus, 158, pp. 888-884, Feb. 2, 1914. Journ. de Physique, 4. Ser. 5. pp. 101-116, Feb., 1914.)—When X-rays are passed through a thin Pt-foil the impression on a photographic plate consists of a patch surrounded by radial stripes [Hupka, Abstract No. 1829 (1913)]. The author finds that each radial stripe shows the spectrum of the particular antikathode used.

In the course of some experiments on absorption of X-rays an interesting phenomenon was noticed. Three photographs of the spectrum of Pt were obtained simultaneously: the first without absorbing screen, the second with a thin sheet of gold as absorber, and the third with a thin sheet of Pt. The photograph with gold as absorber, showed nothing remarkable, but in the photograph with Pt absorber the lines showed an effect similar to a reversal, in that their centres showed the most absorption. This may be explained by assuming that in the production of the rays at the antikathode a phenomenon arises analogous to the Doppler-effect and that the sheet of Pt absorbs selectively by resonance. E. M.

879. Crystalline Structures revealed by Diffraction of Röntgen Rays. G. Friedel. (Comptes Rendus, 158, pp. 180-181, Jan. 12, 1914.)—The author emphasises the necessity of distinguishing in the structure of a crystal between the *space lattice* and the *assemblage*; he considers that the lattice is revealed best by cleavage and the assemblage by diffraction. T. M. L.

880. Röntgen-ray Absorption Band. W. H. Bragg. (Nature, 93, pp. 81-82, March 12, 1914.)—The author has been testing experimentally the theoretical discussions by Debye and Sommerfeld in relation to the influence of molecular motions upon reflecting power. Confirmation has been obtained of some of their predictions which is at least roughly quantitative. For instance, the intensities of the higher order spectra are much more affected by rise of temperature than the lower, and the amount of the change is of the right order of magnitude; also rock-salt and sylvine show greater changes than fluor spar. The results for the diamond have, however, been puzzling. The diamond used was a thin flake which only intercepts a fraction of the incident primary ray, a fraction which diminishes as the diamond is set at a greater angle to the primary beam. Apparently, then, allowance must be made for this waste of reflection opportunities. But the intensity ratios are, to all appearances, nearly correct before the allowance is made, and become quite wrong afterwards. The diamond behaves as if, like the other crystals, it were quite thick. Hence a search was instituted for a special absorption of rays which are undergoing reflection.

A pencil of Röntgen-rays from a rhodium bulb passes through a slit 0.1 mm. wide and falls upon the diamond, which is mounted on the revolving table of a spectrometer. The rays that pass through the diamond fall afterwards upon a crystal of rock-salt so placed as to reflect a pencil into the ionisation chamber. When the diamond is turned, a minute of arc at a time, through the angle (about 9°) at which the diamond itself reflects the principal Rh ray, the intensity of the ray reflected by the rock-salt drops in the ratio 100 to 70. Possibly this ratio could be increased by more accurate arrangement. The principal Rh ray is really a doublet, the two constituents of which are separated by an angle of $4'$ under these arrangements. The doublet is resolved not only in the pencil reflected by the diamond, but also in the absorption band occurring in the reflection from the rock-salt. The effect is no doubt analogous to the selective absorption shown by crystals of potassium chlorate [see Abstract No. 1559 (1908)]. A. W.

881. Counting of α -Particles. L. Myssowsky and K. Nestourkh. (Russian Physico-Chemical Soc., Journ. 45. pp. 149-173, 1918. Le Radium, 2. p. 26, Jan., 1914. Ann. d. Physik, 43. 8. pp. 461-472, Feb. 10, 1914.)—The authors have made experiments with the apparatus originally designed by Rutherford and Geiger for the counting of α -particles [Abstract No. 1627 (1908)]. An insulated wire is fixed along the axis of a cylindrical tube containing air at reduced pressure. α -Particles enter through a mica window and the ionisation due to each is multiplied by collision so as to produce an appreciable effect on an electrometer. The natural disturbances produced in the absence of α -particles were specially investigated. The number and nature of these disturbances depends on the value of the applied potential, the dimensions of the ionisation chamber, and the state of its internal surface. If the surface is well polished and the axial wire well centred they can be made almost insensible. In these conditions, on gradually increasing the potential, a feeble, steady ionisation current is produced in the ionisation chamber, and in this state the apparatus is most favourable for observations [see also Abstract No. 246 (1918)]. E. M.

882. Some Experiments to Detect β -Rays from Radium A. W. Makower and S. Russ. (Phys. Soc., Proc. 25. pp. 253-255; Discussion, p. 255, June, 1918.)—When an atom of radium A disintegrates, an α -particle is expelled which carries with it two positive atomic charges. At the same time the radium B atom formed, recoils with a single positive charge. To account for these facts it is necessary to suppose that three negative electrons are expelled during the process. If these are emitted with a high velocity they should appear as β -rays capable of detection by the ionisation they produce or by their photographic action. On the other hand, they might consist of a slowly-moving ϵ radiation which would escape detection by either of the above methods. The experiments, which were made by both methods in the hope of detecting β -rays from radium A, failed to reveal any such radiation. AUTHORS.

883. Number of Ions produced by the γ -Radiation from Radium. A. S. Eve. (Phil. Mag. 27. pp. 894-896, Feb., 1914.)—If q ions are produced, directly or indirectly, in 1 cm.³ of air at standard temperature and pressure at a distance of r cm. from a source of 2 gm. of radium, then $q = KQ/r^2 e^{-\mu r}$, where K is a constant and μ is the coefficient of absorption of γ -rays in air. Also the total number of ions produced in air by the γ -rays is $N = 4\pi KQ/\mu$. In making measurements of K an electroscope is used with thin walls of low atomic weight, e.g. cardboard. The author has made a redetermination of K and N , and finds $K = 4.0 \times 10^6$ and $N = 8.4 \times 10^{14}$ on the international standard. This latter number excludes the ions produced by easily absorbed radiations, including which Moseley and Robinson found $N = 18 \times 10^{14}$. ["Radioactive Substances," p. 295 (1918)]. E. M.

884. Secondary γ -Radiation. D. C. H. Florance. (Phil. Mag. 27. pp. 225-244, Feb., 1914.)—The author has made a detailed investigation of the emergent and returned secondary γ -radiations from a radiator, using RaEm as a source of primary γ -rays. The experiments confirm the earlier results [Abstract No. 851 (1911)], that the secondary γ -radiation becomes gradually less penetrating the greater the angle it makes with the original direction of the primary beam, and, further, that the secondary γ -radiation is completely heterogeneous. As the primary γ -rays used (RaC) are initially homogeneous, this shows that a continuous transformation takes place in VOL. XVII.—A.—1914.

absorption throughout the whole range of absorbing screens, so that the primary rays cannot remain strictly homogeneous, although an equilibrium of primary and transformed radiation may be set up so as to give an exponential absorption curve. The secondary γ -radiation for all radiators is found to be different in type from the primary radiation, and it appears that in the process of scattering some modification has taken place. In the case of elements such as Pt, Hg, and Pb there is a small amount of an "extra radiation" with an absorption coefficient of about 40 cm.^{-1} in lead. This "extra radiation" is probably characteristic of the radiator. The experiments show, further, that Pb produces more secondary γ -rays than does an equal mass of Al, Zn, or Sn. E. M.

885. *Tables of Radio-active Constants.* L. Kolowrat. (Le Radium, 2. pp. 1-6, Jan., 1914.)—A collection of radio-active information and constants. The following is part of one of the tables. The coefficients of absorption of the various γ -rays are given in Abstracts Nos. 478, 489, and 886 (1914).

Substance.	Valency.	Half-value Period.	Radiation.	Range (α) at 16° C.	Absorption Coefficient μ_β in cm.^{-1} Al.
Uranium I	6	50×10^8 years	α	2.5	—
† Uranium Y	—	1.5 days	β	—	about 300
Uranium X ₁	4	94.6 days	β	—	510
Uranium X ₂	—	1.16 mins.	β	—	14.4
Uranium II	6	2×10^8 years (?)	α	2.9	—
Ionium	4	2×10^8 years (?)	α	3.0	—
Radium	2	1730 years	$\alpha\beta$	3.30	about 200
Radium Emanation	0	3.85 days	α	4.16	—
Radium A	2	5.0 mins.	α	4.75	—
Radium B	2	96.7 mins.	β	—	75
Radium C ₁	3	19.5 mins.	α (?) β	—	13.5
† Radium C ₂ } RaC	—	1.4 mins.	—	—	—
Radium C'	—	10^{-4} sec. (?)	α	6.94	—
Radium D	2	16.5 years	β	—	130
Radium E	3	5.0 days	β	—	43.3
Radium F (Polonium)	2	136 days	α	3.77	—
Radioactinium	4	19.5 days	$\alpha\beta$	4.6	170
Actinium X	2	11.4 days	α	4.4	—
Actinium Emanation	0	3.9 sec.	α	5.7	—
Actinium A	2	0.003 sec.	α	6.5	—
" B	2	36.1 mins.	β	—	very soft
" C	3	9.15 mins.	α	—	—
" D	—	4.71 mins.	β	—	26.5
Thorium	4	1.8×10^{10} years	α	2.72	—
Mesothorium I	2	5.6 years	—	—	—
" II	3	6.3 hours	β	—	about 30
Radiothorium	4	9.02 years	α	3.67	—
Thorium X	2	3.64 days	α	4.30	—
Thorium Emanation	0	54 sec.	α	6.00	—
Thorium A	2	0.14 sec.	α	6.70	—
Thorium B	2	10.6 hours	β	—	110
Thorium C ₁	3	60 mins.	$\alpha\beta$ (?)	4.80	} 16.3
† Thorium D	—	3.1 mins.	β	—	
Thorium C ₂	—	10-11 sec. (?)	α	8.60	—
Potassium	1	—	β	—	about 30
Rubidium	1	—	β	—	about 300

E. M.

886. *γ -Rays from Uranium Products.* H. Richardson. (Phil. Mag. 27. pp. 252-256, Feb., 1914.)—The experiments show that $\text{UrX} (= \text{X}_1 + \text{X}_2)$ emits three types of γ -rays having absorption coefficients in Al $\mu = 24$, $\mu = 0.70$, VOL. XVII.—A.—1914.

and $\mu = 0.140$ (cm.)⁻¹. The first two types probably belong to Urx_1 ; the third, penetrating type, to Urx_2 . The results support the view that the atomic weight of actinium is about 280, and that Ac is probably a branch product from Urx_1 . [See Abstract No. 487 (1914).] E. M.

887. *Decay Constant of Actinium X.* H. N. McCoy and E. D. Leman. (Phys. Zeitschr. 14. pp. 1280-1282, Dec. 15, 1918.)—A redetermination of this constant [see Abstracts Nos. 1588 (1905), 1298 (1918)]. Godlewski's value 10.2 days is probably too low. Harn and Rothenbach find 11.6 days. The authors arrive at the value 10.85 days. E. E. F.

888. *Penetrating Atmospheric Radiation.* W. Kolhörster. (Phys. Zeitschr. 14. pp. 1066-1069, Nov. 1, and pp. 1158-1155; Discussion, pp. 1155-1156, Nov. 15, 1918. Paper read before the 85. Naturforscherversammlung, Wien. Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1111-1116, Nov. 15, 1918.)—The apparatus used in three balloon voyages from Bitterfeld was a Wulf-Hess double-fibre electrometer closed air-tight, and the errors are estimated not to exceed 10 or 15 per cent. The measurements show an increase in the penetrating radiation with the height in all three voyages, but most of all in the first voyage, which passed over the (highly radio-active) Erzgebirge. The author believes this increase is not due to any known radio-active substance. In the discussion, Gockel mentioned having come to the same conclusion from measurements on glaciers. Bergwitz thought that the increase might be a temperature effect. But the Author replied that a temperature effect would be in the opposite sense to the effect observed. E. E. F.

889. *Helium in Coal-mine Gas and the Radio-activity of Coal.* C. Moureu and A. Lepape. (Comptes Rendus, 158. pp. 598-608, March 2, 1914.)—Mine gases, and especially blowers, contain quantities of helium, which are much greater than those found in mineral waters. The authors find that the Anzin blower yields 12 m.³ of helium daily, or 4380 m.³ annually; the Frankenholz blower yields, according to Guntz, 8650 m.³ per year, the gas outbreak at Neuengamme yielded, according to E. Czako, even 25,550 m.³ of helium per year. The radio-activity of the mine gas proved too weak for determination. The quantities of radium and thorium in the coal estimated after R. J. Strutt and J. Joly (burning the coal and examining the ashes), yielded the following weights of radium (and thorium) expressed in 10⁻¹⁸ gm. per gm. of coal: at Liévin, < 0.02 (—); Anzin, < 0.01 (0.01); Lens, 0.97 (0.88); Frankenholz, 0.04 (0.08); Mons, < 0.01 (0.02). Calculations made for Frankenholz show that only a very small portion of the helium could have been produced by the radio-active elements in the coal. On the other hand, it is noteworthy that helium is, in mine gases and other natural gases, always accompanied by the other rare gases, neon, argon, krypton, xenon, which certainly could not have been produced in the coal. An estimate of the radio-active components in the rocks of coal-beds cannot account for the helium found either. H. B.

890. *Radio-activity of Japanese Mineral Springs.* D. Isitani. (Mathematico-Physical Soc., Tokyo, Proc. 7. pp. 221-225, Jan., 1914.)—The paper relates to the emanation content of eleven springs with temperatures varying from 18° C. to 91° C., the average content being about 400×10^{-18} curie per litre of water. E. M.

HEAT.

891. Apparatus for the Determination of Gas Isotherms up to about 8000 Atmospheres. P. Kohnstamm and K. W. Walstra. (Konink. Akad. Wetensch. Amsterdam, Proc. 18. pp. 754-789, Feb. 26, and pp. 822-825, March 26, 1914.)—The authors describe the essential features of the apparatus gradually evolved for the measurement of the pressures and volumes of gas under pressures as high as 8000 atoms. For the details of the apparatus and of the method of calibrating it, the original should be consulted. T. H. P.

892. Calibration of Thermometers by Floating Equilibrium. T. W. Richards and J. W. Shipley. (Amer. Chem. Soc., Journ. 86. pp. 1-10, Jan., 1914.)—By using a hollow float of quartz or glass immersed in a solution of known concentration it is possible to determine the temperature of floating equilibrium within about 0.001° C. These floats may therefore be used for the calibration of thermometers, when once the necessary relationship between temperature and concentration has been established.

In checking the weights of the floats it was found that difficulty in weighing arose in part from electrostatic effects, since the errors disappeared at once when a tube of radium bromide was present in the balance case.

T. M. L.

893. New Calorimetric Resistance Thermometers. H. C. Dickinson and E. F. Mueller. (Bureau of Standards, Bull. 9. pp. 488-492, 1918.)—A general description of an improved form of calorimetric resistance thermometer is given, together with some points of interest in connection with its use. The essential features of such a thermometer, to which attention has been given, are enumerated. A difference formula for simplifying calorimetric computations is developed in the paper, and its applicability shown. F. J. H.

894. Latent Heat of Fusion of Ice. H. C. Dickinson, D. R. Harper, and N. S. Osborne. (Bureau of Standards, Bull. 10. pp. 285-286, 1918.)—After giving a brief review of previous determinations of the latent heat of fusion of ice, the authors describe in detail their investigation of this constant by two independent calorimetric methods. The first of these is the ordinary method of mixtures, the temperature measurements in which are made by means of sensitive Pt-thermometers [see preceding Abstract], and the corrections inherent in the method very carefully determined; the second is an electrical method, in which the electrical heating serves to reduce the usual calorimetric corrections to an almost negligible quantity by keeping the temperature of the calorimeter near that of its surroundings. The method of procedure was to cool the samples of ice prepared in the form of hollow cylinders containing from 100 to 500 gm. to either -0.72° or -8.78° , in specially constructed cryostats, weighing while at these temperatures, and then introducing them rapidly into the water of the calorimeter. The results of the determinations carried out on 92 specimens indicate that for commercial can ice, commercial plate ice, natural ice, ice frozen in the laboratory from air-free double-distilled water, and from double-distilled water containing air, all of which were very pure as indicated by electrical

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conductivity tests, the heat of fusion is the same to within the limits of accuracy of the earlier determinations, viz. 1 part in 1000. Further experiments on the three commercial forms of ice fail to show differences greater than about 1 part in 5000. The mean of the final 21 determinations gives for the latent heat of fusion 79.68 cal., the calorie being that at 15° C. Five observations on ice contaminated with a mixture of ammonia, NaCl and CaCl₂ to the extent of about 1 part in 1000 give results about 1.4 % lower than for pure ice.

F. J. H.

895. *The Ice Calorimeter. With Remarks on the Constancy of the Density of Ice.* E. Griffiths. (Phys. Soc., Proc. 28. pp. 1-14; Discussion, pp. 14-15, Dec., 1918.)—The author has redetermined the value of the constant of the ice calorimeter. The latter was placed in a Dewar vessel surrounded by ice, and heat was added electrically, the potential at the ends of the heating coil being determined by balancing against a known number of standard cadmium cells; the resistance of the heating coil being also determined. Assuming $J = 4.184$ and the e.m.f. of the standard cadmium cell at 20° to be 1.01880, the author finds the constant of the ice calorimeter to be 15.486 mgm. of mercury per mean calorie. The author has calculated from this result the latent heat of fusion of ice, and finds it to be 80.80 mean calories, a number higher by 0.7 per cent. than that most recently determined by Smith (viz. 79.77); a discrepancy which the author attributes to the presence of occluded water in the ice used by Smith. The author regards the evidence which has been adduced by various observers, in favour of ice having a variable density, as not being conclusive. In the *discussion*, Callendar pointed out the uncertainty in the author's calculation of the latent heat of fusion of ice owing to the uncertainty in the value for the density of ice. Taking the value 0.9167 for the density of ice (Barnes) instead of 0.9161 as employed by the author, the latent heat calculated would be 79.5 (approx.).

A. F.

896. *Melting-point of Arsenic.* R. Goubau. (Comptes Rendus, 158. pp. 121-122, Jan. 12, 1914.)—Highly purified arsenic is found to melt at 817° and to possess a considerable vapour pressure even far below this temperature.

T. H. P.

897. *Heat Resistivity of Carbon and Graphite.* J. W. Richards. (Amer. Electrochem. Soc., Trans. 24. pp. 109-112; Discussion and Communications, pp. 112-118, 1918. Metallurgical and Chem. Engin. 11. p. 575, Oct., 1918. Abstract.)—The paper describes briefly observations made by J. P. Stokes and A. D. Jamieson upon the heat resistivities of carbon and graphite. Two blocks are cut in such a way that when placed together they form a cube of 20 cm. side, having a central cubical cavity of 2.5 cm. side. Heat is supplied to the inside by a 1000-watt arc formed between electric-light carbons introduced through closely-fitting glass tubes. The temperature at a point 1 mm. from the surface of the central cavity is measured by means of an iron-nichrome thermo-couple. In calculating the thermal resistivity, the cube is considered to be split into six truncated square pyramids. The thermal resistivities of carbon (202° to 853° C.) and of graphite (240° to 420° C.) are found to be 86.8 and 8.69 degrees per watt respectively. The ratio of these, viz. 10:1, is considered to be a minimum since the temperature of the outside was measured at the centres of the faces, which were warmer than the corners. For purposes of comparison a number of investigations by other observers are briefly abstracted. In the *discussion*, the paper was severely criticised, chiefly in regard to the correctness of the measured temperature gradient.

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898. *Some Aspects of Heat-flow.* E. F. Northrup. (Amer. Electrochem. Soc., Trans. 24. pp. 85-106; Discussion, pp. 106-107, 1918. Metallurgical and Chem. Engin. 11. pp. 572-574, Oct., 1918. Abstract.)—After dealing at some length with the analogies and dissimilarities between the flow of heat and of electricity and with the difficulties in measuring thermal conductivity as compared with electrical conductivity, the author describes new methods of measuring thermal conductivity which he has devised and which have been suggested by the electrical analogies. The following four methods of measuring electrical resistance are considered in their application to thermal problems: (1) Measurement of the fall of potential and current. (2) Comparison between the fall of potential along the specimen and that along a standard resistance. (3) Wheatstone's bridge method. (4) Kelvin double bridge method. The usual method of measuring thermal conductivity by measuring the quantity of heat flowing and the temperature gradient is analogous to method (1). In regard to the second method the author has applied it very successfully for measuring the thermal resistance of the surface of contact between two bodies. Two cylindrical copper rods 8.8 cm. in diam. were pressed together end to end and the temperature-fall in equal lengths of 10 cm., one of which included the contact, were measured and compared. In this way the thermal resistance of the contact was obtained in terms of that of the copper. The author considers that the extension of this method to the comparison of the thermal conductivities of two materials would meet with success. There is no exact thermal analogy to method (3), but the method devised by the author and applied by W. Eves [see Abstract No. 12298 (1918)] to the comparison of the thermal conductivities of various impregnating insulation compounds was suggested by it. With regard to the Kelvin double bridge method its application to the comparison of thermal conductivities is suggested, the potential leads in the electrical arrangement being replaced by thermo-couples which supply the current for the bridge. A zero method of comparing thermal conductivities is thus obtained. On account of the simplicity of the foregoing methods the author advocates the use of standards of thermal resistance in the same way that standards of electrical resistance are used; he also suggests the use of electrolytic copper as the standard of low thermal resistance and of a specified grade of alundum cement as the standard of high thermal resistance. F. J. H.

899. *Flow of Heat through Furnace Walls.* I. Langmuir, E. Q. Adams, and G. S. Meikle. (Amer. Electrochem. Soc., Trans. 24. pp. 58-76; Discussion and Communications, pp. 76-84, 1918. Metallurgical and Chem. Engin. 11. pp. 574-575, Oct., 1918.)—The quantity of heat conducted through a body of any shape is given by the formula, $Q = S \int_{T_0}^T k \cdot dT$, where

k is the conductivity, T_0 and T are the temperatures of the two faces of the body and S is a quantity, termed the shape factor, which has the dimension of length and which depends only upon the shape and size of the body. It is only in the cases of parallel plane surfaces, concentric cylinders, and concentric spheres, however, that a rigorous calculation of the shape factor can be made. In other cases certain simplifying assumptions must be made, so that the results are of limited accuracy only. However, by assuming, first, certain shapes for the isothermal surfaces, and secondly, certain shapes for the lines of flow of heat, the authors find it possible to get two expressions for the shape factor, the first of which gives values obviously too high and the

second values obviously too low; the two, however, lie between narrow limits. Also, very good approximate results can often be obtained by imagining parts of the surface of inflow and outflow of heat to be replaced by spheres or cylinders of equal area. In addition to the theoretical investigation on the above lines the authors have verified the formulæ by experiment, results lying between the upper and lower limits being obtained. The experimental work consisted in measuring the electrical resistance of a saturated copper sulphate solution containing 0.5 % by volume of sulphuric acid, this solution being contained in vessels made up of suitable copper and glass plates and having shapes similar to those for which calculations had been made. The shape factor was obtained from the electrical resistance by comparison with that of a standard decimetre-cube with two opposite sides of copper. The shapes chosen for test represented elementary parts of cubes, prisms, cylinders, planes, etc., and in each case by varying the depth of the electrolyte in the cell the effect of the proximity of edges and corners could be tested. The results of the investigation are summarised at the end of the paper and an example of the calculation of the shape factor in a specific case is given. The results differ considerably from those calculated by two approximate methods in common use. In a communication to the *discussion*, E. F. Northrup pointed out that the determination of the shape factor to such a high degree of precision is not of very great importance in such problems as the conduction of heat through furnace walls as many other uncertain factors of large relative importance are involved. The determinations should, however, be of great use in the important problem of determining experimentally the thermal conductivity of heat insulators. Formulæ are developed by means of which the temperature of any point in the material can be determined from the known temperatures of two other points in the case of parallel planes, concentric spheres or concentric cylinders. J. W. Richards pointed out that the experimental results of the paper really only apply to the very special case in which the inner and outer surfaces are isothermals.

F. J. H.

900. *Calorific Effects of Foule and Siemens*. L. Decombe. (Journ. de Physique, 4. Ser. 5. pp. 116-126, Feb., 1914. Comptes Rendus, 158. pp. 988-941, March 30, 1914.)—The electronic theory applied to metals as developed by Riecke, Drude, and Lorentz on the one hand, and by J. J. Thomson on the other, is here utilised by the author for the purpose of interpreting the laws of electric and calorific conductivity. It is found to explain satisfactorily the reversible Peltier and Thomson effects, but certain difficulties are encountered with the Joule-effect. The similarity of the latter to that of Siemens is pointed out, and the author believes the point of view developed in the present paper to furnish the elements of a new theory of metals. Drude and Lorentz's electronic theory is examined in detail and the Peltier and Thomson effects are shown to be capable of easy explanation on it; for in a homogeneous metal the number of free electrons per unit volume is constant for a given temperature but variable from one metal to another. If then two metals be considered in contact at the same temperature, it is necessary, in order to satisfy the equation of continuity, to admit the existence of a thin transition layer in which the number varies very rapidly. This variation determines the appearance of an e.m.f. normal to the layer and capable of compensating the diffusion current which the heterogeneity of distribution tends, on the other hand, to establish. The positive or negative

work effected upon this e.m.f. by a current traversing the layer may therefore be identified with the Peltier-effect. In an analogous manner every variation of temperature in an homogeneous metal brings about an e.m.f., which thus explains the Thomson-effect. It is otherwise with the Joule-effect, for on Drude's exposition the mechanism is that at the instant of impact the electrons lose the excess of kinetic energy communicated by the field since the preceding impact. Now the electrons could only have given up this excess of kinetic energy to the neutral atoms of the metal, and the author gives a mathematical exposition to show that the nature of the impact, considered on purely kinetic grounds, is incapable of satisfying this condition. The second form of the theory developed by J. J. Thomson in his corpuscular theory of matter proceeds from an entirely different standpoint, and is next examined by the author. In this theory electrons are expelled from each atom by the action of surrounding atoms, which latter are comparable to doublets formed of negative electrons and suitable positive charges. Moreover, every expelled electron is supposed to be immediately captured by a neighbouring atom. When the axes of the doublets are in every direction, no current exists since the flux of electrons from the reciprocal exchanges is not specifically orientated. If, on the other hand, the doublet directions be more or less completely polarised by an external field, there will be, parallel to the field and in a contrary sense, an excess of moving electrons which constitute the current. The present author now finds that J. J. Thomson's theory will give indirectly an interpretation of Joule's effect as well as directly that for Peltier and Thomson. He assumes that the phenomena of metallic and electrolytic conduction take place through the successive liberation and recombination of electrons or ions, and that there result changes in the final speeds which disengage heat. This heat evolution is a consequence of a special atomic viscosity bound up with fluctuations in the orbital movement of the electrons.

The present paper is a development of this point of view, the atom being regarded as a complex of small orbital electron systems called by the author "spectrons." Each electron liberated is immediately captured by a neighbouring spectron as in J. J. Thomson's theory, but the mechanism of expulsion differs from that proposed in the latter theory in that it is assumed as due to the electric field and not to the influence of neighbouring spectrons, so that in the absence of the field atomic dissociation is non-existent. During the action of the field, and only then, may each spectron be regarded as an electric doublet having its axis parallel to the field. The author then demonstrates how the fundamental laws and the various effects are directly established on this theory. Finally he puts forward suggestions based on this standpoint for a new theory of metals which shall satisfactorily interpret thermal conductivity and the effects of Peltier, Thomson, Hall, etc. H. H. HO.

901. *Constants of Spectral Radiation of a Uniformly Heated Enclosure.* W. W. Coblentz. (Bureau of Standards, Bull. 10. pp. 1-77, Jan. 15, 1914.)—The present paper gives data relating principally to the determination of the mathematical form of the isothermal spectral curve of a black body, and to the computation of the numerical value of the constants relating thereto, for the temperature-range between 450° and 1525° C. The paper also contains data on various subsidiary problems such as (i) the variations of the reflecting power of silver with angle of incidence and with wave-length, (ii) the variation of the reflecting power of fluorite with angle of incidence and with wave-length, (iii) data on the most reliable refractive indices of fluorite, reduced to VOL. XVII.—A.—1914.

20° C., and (iv) data for reducing the observations from prismatic to normal spectrum. The spectrum was produced by means of a mirror spectrometer and a fluorite prism. A vacuum bolometer was used for measuring the partition of energy in the spectrum. The radiator was a porcelain tube, wound with Pt-ribbon through which an electric current was passed. In a brief summary the results of previous investigations made with similar apparatus are discussed. It is shown that by the elimination of certain errors in the calibration of the prisms used, the older observations are not in disagreement, as was supposed from the published results. These older data (properly weighted) are therefore used in connection with the present-day results, to form an estimate of the most probable value of the constants of spectral radiation. The results obtained in the present investigation are based upon experiments with different bolometers, water-cooled shutters, fluorite prisms, thermo-couples, and radiators (blackened and unblackened). The success attained is attributed to blackening the radiator, to properly insulating the thermo-couples within the radiator, to placing a knife-edge support beneath the inner radiator to prevent it sagging, and to projecting an image of the radiating diaphragm upon the spectrometer slit. It is shown that the percentage of the total number of energy-curves which fit the Planck equation is increased by blackening the radiator. About 75 % of the reliable energy-curves fit the Planck equation, the validity of which was assumed in order to compute the radiation constants from the observed data. This involves a temperature-range greater than 1000°. Within this temperature-range there is a tendency for the constants to increase slightly with temperature, in several sets of observations, but this slight variation is not sufficiently systematic to be considered an actual departure from the theoretical (Planck) law upon which the computations are based. The mean values deduced from eight sets of observations (including 94 of the best spectral energy curves) are $C = 14,456 \pm 4$ mikron deg., $A = 2911 \pm 1$ mikron deg. The weighted mean value of the results of Lummer and Pringsheim, Paschen, Coblentz, and Warburg is $C = 14,420$ and $A = 2905$. As a result of the calibration of the thermo-couples used it was later found that the above mean value ($C = 14,456$) should be increased to $C = 14,465$. The latest results of Hoffmann and Meisner on the ratio of brightness of two black bodies at the melting-points of gold and of palladium, using an optical pyrometer, gives a value of $C = 14,440$. The value now commonly used is $C = 14,500$, and from present indications there appears to be no immediate need to adopt a new value. [See also Abstract No. 640 (1918).] A. W.

902. *Theory of Specific Heat*. D. A. Goldhammer. (Phys. Zeitschr. 14. pp. 1185-1189, Dec. 1, 1918.)—Gives a simplified method of evaluating the number of proper frequencies of isotropic and ælotropic bodies within a certain interval of frequency. It is based upon the method used by Rayleigh and by Jeans (1905) for elastic bodies in the theory of radiation. The final formula represents a generalisation of Debye's formula which makes it applicable to crystals. E. E. F.

903. *Specific Heat*. M. Trautz. (Phys. Zeitschr. 14. pp. 1176-1178, Nov. 16, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—Attempts to work out a "chemical" theory of specific heat which shall account for the low values obtained at low temperatures and agree with the quanta theory. Gases are taken as constituted by a large but finite number of isomers of the same molecular weight, which change into each

other at a very rapid rate, even down to absolute zero. In the case of H and N the assumption of only two isomers of constant molar heat $8/2R$ and $5/2R$ gives a close agreement with observation as regards heat of transformation, dissociation, the integration constant, and other constants. It yields a quantitative and very graphic interpretation of the rise of chemical affinity with temperature. The view of anomalous specific heat is much like that of anomalous vapour pressures with which we are already familiar. E. E. F.

904. Space-lattice Vibrations and Specific Heats of Solids. I. H. Thirring. (Phys. Zeitschr. 15. pp. 127-188, Feb. 1, 1914.)—The quanta theory, in the works of P. Debye, of Born, and of v. Kármán, has furnished relations between the specific heats of solids and their elastic constants which so far seem satisfactory. This line of thought is here worked out mathematically for substances with diatomic molecules such as rock-salt. [See Abstracts Nos. 446, 626 (1918), 266 (1914), and next Abstract.] E. H. B.

905. Space-lattice Vibrations and Specific Heats. II. H. Thirring. (Phys. Zeitschr. 15. pp. 180-185, Feb. 15, 1914.)—The theory of Born and Kármán for space-lattice vibrations is extended to lattices in which different masses alternate; this enables one to calculate the relation between the elasticity and the specific heat at low temperatures for regular crystals with more than one atom in the molecule. The calculation is carried out for NaCl, KCl, CaF₂, and FeS₂. The results show a mean deviation of 2.8 % and a maximum of 4 % from the observed values. [See preceding Abstract.] E. H. B.

906. Combustion of Gaseous Mixtures and Velocities of Reaction. Taffanel. (Comptes Rendus, 158. pp. 42-45, Jan. 5, 1914.)—Theoretical considerations dealing with the results previously obtained [see Abstracts Nos. 280, 281 (1914)]. T. H. P.

907. Vapour Pressure of Metallic Tungsten. I. Langmuir. (Phys. Zeitschr. 14. pp. 1278-1280, Dec. 15, 1913.)—Shows that the vapour pressure p of a substance is connected with its rate of evaporation m in a vacuum by the equation $m = (M/2\pi RT)^{1/2} p$, where M is the molecular weight of the vapour. In deducing the equation, it is assumed that all molecules of a metallic substance impinging on the surface of the metal are condensed, and none reflected. Experiments to determine the rate of evaporation of tungsten were made at temperatures ranging from 2440° to 3186° abs. Within that range the rate of evaporation increased in the ratio of 1 : 15000. The vapour pressure thus found agrees excellently with the thermodynamic formula of Clausius and Clapeyron. The heat of vaporisation for 184 gm. of solid W is thus (21780 - 1.8 T) cal. This is greater than the heat developed in any chemical reaction. The rate of evaporation of tungsten in a perfect vacuum at a temperature T is given accurately by the equation $\log m = 15.402 - 47440/T - 1.4 \log T$, m being reckoned in gm. per cm.² and sec. The vapour pressure of tungsten in mm. of Hg at temperature T abs. is given by $\log p = 15.502 - 47440/T - 0.9 \log T$. The vapour pressure of tungsten at 2400° abs. (the temperature of the filament in a lamp giving 1 c.p. per watt) is about 50×10^{-9} mm. At the melting-point of tungsten, 3540° abs., the vapour pressure is 0.080 mm. The boiling-point of tungsten at atmospheric pressure is probably close to 5100° abs. At 2000° abs. it is 6.45×10^{-12} mm. E. E. F.

908. Absolute Zero Entropy-Changes on Mixing. W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 669-678, Jan. 29, 1914. Comm. Phys. Lab., Leiden, Supplement No. 88. Phys. Zeitschr. 15. pp. 217-220, VOL. XVII.—A.—1914.

March 1. *Erratum*, p. 868, April 1, 1914.)—According to Planck's version of the Nernst heat theorem the entropy of a one-component substance in a condensed state approaches to a finite value, which is independent of the pressure and of the special state of aggregation, when the absolute temperature approaches to 0. That value may be taken as a suitable zero-point for the entropy of that substance in the condensed state. General considerations are shown to suggest that for a mixture also the entropy at the absolute zero-point is equal to 0, if this is the case for the components, by the choice of this point as a zero-point for the corresponding entropies. According to a remark by Nernst [Abstract No. 682 (1918)] the equipartition law fails in an ideal gas approaching zero, so that the temperature is not determinable by a gas thermometer, but may be determined theoretically from the energy density of the radiation in equilibrium with it. Calculation on the assumption that the molecular volume does not become infinite for $T = 0$ confirms the above conclusion by showing that at the absolute zero the entropy-change on mixing two ideal gases is equal to 0. Further confirmation is obtained mathematically from relations for the equation of state in an ideal gas obtained by the author in a former paper [Abstract No. 288 (1914)]. G. W. DE T.

909. *Wien's Radiation Formula from the Assumption of Independent Light-quanta*. G. Krutkow. (Phys. Zeitschr. 15. pp. 188–186, Feb. 1, 1914.)—It is here shown mathematically that Wien's radiation formula (and not Planck's) follows from the two following assumptions:—

I. A resonator of the frequency ν can only possess energy of the values, 0, $h\nu$, $2h\nu$,....

II. These energy values are formed by the juxtaposition of elementary amounts of energy $h\nu$, which are independent of each other. [See Abstracts Nos. 1562 (1905), 445 (1914).] E. H. B.

910. *Note on the Heat of Formation of Hydrogen from Hydrogen Atoms*. I. Langmuir. (Phil. Mag. 27. pp. 188–189, Jan., 1914.)

911. *Kinetic Theory of Perfect Gases*. E. Bouty. (Journ. de Physique, 4. Ser. 5. pp. 5–16, Jan., 1914.)—Discusses on the kinetic theory the equilibrium of a perfect gas under gravity, and thus obtains for the height of the atmosphere the usual formula $h = \gamma/(\gamma - 1) \cdot RT_0/g$. E. H. B.

912. *Boltzmann Theorem and Energy Quanta*. P. Ehrenfest. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 591–597, Jan. 29, 1914.)—A mathematical discussion of the legitimacy of the mixture of classical and non-classical mechanics which occurs in connection with a mechanical theorem of Boltzmann and the energy quanta of Planck. E. H. B.

913. *Natural Vibrations and Specific Heats*. M. Born. (Phys. Zeitschr. 15. pp. 185–191, Feb. 15, 1914.)—A mathematical discussion of these problems on Planck's theory. [See Abstracts Nos. 626 (1918), 19 (1914).] E. H. B.

914. *Undamped Vibrations and Planck's Radiation Theory*. C. W. Oseen. (Ann. d. Physik, 43. 4. pp. 659–651, Feb. 27, 1914.)—A mathematical discussion of the possibility of the existence of undamped vibrations on Maxwell's theory, and with reference to Planck's radiation theory. [See Abstract No. 1826 (1918).] E. H. B.

915. *Derivation of the Canonical Form of the Equation of State from Statistical Mechanics*. A. Wassmuth. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 651–666, March, 1918.)—Mathematical. Supplementary to the work of Ornstein and of Planck [Abstract No. 1455 (1908)].

SOUND.

916. Range and Sharpness of Resonance and their Variations with Pitch. E. Waetzmann. (Phil. Mag. 27. pp. 467-468, March, 1914.)—The author entirely agrees with E. H. Barton [see Abstract No. 1701 (1918)] as to the distinction between coefficient of damping and logarithmic decrement, but also points out that in respect to the ear he had already recognised this (E. Waetzmann, "Die Resonanztheorie des Hörens als Beitrag zur Lehre von den Tonempfindungen," Braunschweig, 1912; Bemerkung über die Dämpfung der Ohr-resonatoren, Schlesisch. Gesell. Sitzung vom 28 Mai, 1918). Whereas Helmholtz in his theory of hearing assumes that all the resonators of the ear have the same logarithmic decrement—that they have, therefore, disregarding certain negligible factors, the same sharpness of resonance—the author has suggested and critically examined the hypothesis that it is not the logarithmic decrement, but rather the damping coefficient of all the resonators of the ear for the ordinary compass of the audible scale, which remains approximately the same. In working out this theory, the author had calculated quantitatively the dependence of the sharpness of resonance on the proper frequency of the resonator, and found that known facts agree better with this theory than with that of Helmholtz. E. H. B.

917. Recording of Acoustic Vibrations by means of Wulf's String Electromotor. G. Gianfranceschi. (Accad. Lincei, Atti, 22. Part II. pp. 218-221, Sept. 7, 1918.)—The method adopted was to use a microphonic transmitter connected in series with the primary of a large induction coil without interrupter, the secondary terminals being connected to the electrometer and to earth respectively. A number of oscillograms are given showing the vibrations corresponding to the five vowels sung upon the same note (*c'*). Further results are to be published, the present being a preliminary account. L. H. W.

918. Enlargement and Reduction of Gramophone Records. G. A. Le Roy. (Comptes Rendus, 158. pp. 175-177, Jan. 19, 1914.)—Describes a method by which discs or cylinders may be enlarged or reduced. A cast or matrix is taken by copper deposition and then an aqueous solution of gelatine is used for enlargements. Other and various substances are used for reductions. The changes of size desired are obtained by successive small stages in the elastic material. A photographic reproduction shows an enlarged and a reduced disc, one double the diameter of the other, and both derived from the same original. E. H. B.

919. Aural Illusion. N. Alliston. (Nature, 92. p. 61, Sept. 18, 1918.)—If a sounding body had a velocity greater than that of sound in air, it would outstrip its previous sounds as it went, and leave them to follow in its wake. Suppose such a body ceased sounding on passing an observer. Then the sounds last emitted would be heard first and heard loudest because the body
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was so near when emitting them. In such circumstances, therefore, it would seem to the observer that the source of sound had been receding instead of approaching. This is quite distinct from the Doppler-effect on the pitch.

E. H. B.

920. *Whispering Galleries.* Rayleigh. (Phil. Mag. 27. pp. 100-109, Jan., 1914.)—The author here further applies Bessel's functions of high order to the whispering gallery and allied problems. The analysis confirms the expectation that the whispering-gallery effect does not require a perfectly reflecting wall, but that the main features are reproduced in transparent media, provided that the velocity of waves is moderately larger outside than inside the surface of transition, and further, the less the curvature of this surface the smaller is the refractive index (greater than unity) which suffices.

E. H. B.

921. *Air-pressures used in Playing Reed Instruments.* C. W. H. Foord. (Phil. Mag. 27. pp. 271-277, Feb., 1914.)—In W. H. Stone's work, "Elementary Lessons on Sound," a table is given showing the maximum and minimum wind-pressures used in playing various instruments. This table gave for the clarinet 15 in. to 8 in. of water-pressure. For each of the other instruments, the oboe, bassoon, horn, cornet, trumpet, euphonium, and bombardon the pressures given occur in the opposite order, the lower ones occurring first. It was shown by E. H. Barton and S. C. Laws that for the cornet, trumpet, and trombone the higher pressures are for higher notes [see Abstract No. 1584 (1902)]. The question accordingly arose, Is the clarinet unique in this respect? or, Was the 8 a misprint for 18, as assumed by some writers? The present author has settled this point by a series of experiments which show that as the pitch of the notes rises in the clarinet the pressure usually falls. Thus on the B \flat clarinet played *forte* 15.5 in. of water was used for the lowest note (E) and 9.5 for the G \sharp more than three octaves higher. Playing *piano*, the pressures ranged from 6.5 to 4.25. The pressure curves for the clarinet show a slight rise with pitch for about a tone near the middle of the compass succeeded by a fall to the extreme limit.

On the E \flat saxophone played with a single reed the pressure is greatest near the middle of the compass, falling off slightly at top and bottom. The E \flat saxophone played with a double reed showed higher pressures for the higher notes.

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

922. *Mass of Moving Electrons.* C. Schaefer and G. Neumann. (Phys. Zeitschr. 14. pp. 1117-1118, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—The authors repeated Bucherer's experiments concerning the dependence of mass upon speed [Abstract No. 1998 (1908)] which were claimed as a confirmation of the Lorentz-Einstein principle of relativity, but criticised by Bestelmeyer [Abstract No. 1549 (1911)]. The new results completely confirm Bucherer's work, and decide the question of Abraham's as against Lorentz's electron in favour of the latter. E. E. F.

923. *Free Electrons in Metals.* K. F. Herzfeld. (Phys. Zeitschr. 14. pp. 1119-1121; Discussion, pp. 1121-1122, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—The number of free electrons in metals has been estimated (a) from the conductivity and probable free path; (b) from the reflective power; (c) from the Hall-effect; and (d) from the current obtainable from incandescent solids. All those methods give fairly concordant results, indicating a number amounting to about $1/8$ of the number of metallic atoms. But that raises a difficulty regarding the specific heat of electrons, which ought to produce a difference between conductors and insulators as regards Debye's formula. The author attempts a new calculation from the entropy constant, regarding the dissociation of electrons as an "evaporation" from the molecules, and using Stern's method, which does not involve quanta. This reasoning makes the number of electrons about $1/600$ th of the number of atoms. The author acknowledges that the reasoning is not free from objection, but urges that all the other methods are equally open to criticism. E. E. F.

924. *Pulsating Electrons and Quanta.* A. Korn. (Phys. Zeitschr. 14. pp. 1109-1112, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—Points out that the main difficulty in the hydrodynamical analogies of electromagnetic phenomena, viz., that of the attraction between quantities of the same sign, may be overcome by postulating a fundamental individual, permanent, and characteristic rate of pulsation for the electrons or other ultimate elements. The energy of this pulsation may be called the "pulsation quantum." The author suggests that d'Alembert's principle may be usefully supplemented by a principle of "the conservation of individuality" as regards fundamental frequency. The frequencies are of a higher order than those familiar to us in optical and electrical theory.

The permanence of atoms may be more safely based upon frequency than upon geometrical shape. E. E. F.

925. *Corpuscular Radiation.* H. Bateman. (Phil. Mag. 26. pp. 579-585, Oct., 1918.)—Mainly a study of one type of electromagnetic field having as its chief characteristic a corpuscular type of radiation. Mathematical. L. H. W.

926. *Specific Inductive Capacities of Liquids.* C. Gutton. (Comptes Rendus, 158. pp. 621-628, March 2, 1914.)—If, as Voigt suggested, the force acting on an electron in an electric field were not exactly proportional to its
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displacement, the value of the specific inductive capacity would undergo variation with the strength of the field. The author has examined the specific inductive capacities of various liquids by using them as insulators in a condenser forming part of a resonating circuit. This circuit was made to respond to the electric oscillations in Blondlot's arrangement of two parallel wires joined together at any point by a cross-wire. The currents in the resonator circuit were measured by a galvanometer and the distance between the two positions of the cross-wire for which the oscillations in the resonator were a minimum gave the half-wave-length to which the resonator was tuned. This being proportional to the square root of the specific inductive capacity of the liquid in the condenser, it was found that on increasing the intensity of the waves in the ratio 1:10 the wave-length remained (within the limits of experimental error) constant for toluene or CS₂, while in the case of liquids of greater specific inductive capacity, such as bromonaphthalene, there was a slight diminution. The specific inductive capacities found were, at 16° C.: toluene 2.86; CS₂ 2.61; bromonaphthalene 4.72 to 4.69.

J. W. T. W.

927. *A New Form of Electric Wind.* S. Ratner. (Comptes Rendus, 158, pp. 565-567, Feb. 28, 1914.)—It is generally known that in strong electric fields the intense ionisation by collision is accompanied by a motion of the gas itself. Some strange effects observed in connection with the recoil of radio-active atoms have led to the revelation of the same phenomenon in other cases of conduction in an ionised gas. This fact, which is of considerable importance, since it probably affects measurements in radio-activity generally, can be made evident by a simple experiment. To one plate of an air condenser is attached on the inside a small plate coated with radio-active material to ionise the air. The other plate is earthed and carries a metal tube perpendicular to it, having at its outer end a small suspended vane. By reason of the air current set up by the motion of the ions this vane becomes deflected as soon as the condenser is charged. The arrangement is very sensitive, an ionisation current of 10^{-10} amp. being sufficient to cause an appreciable deflection. The following facts have been observed in connection with the air-current:—The force exerted on the vane is larger for the positive ions than for the negative, the difference between the two being greater the smaller the distance between the plates; it is roughly proportional to the amount of ionisation. For small fields the force is proportional to the intensity, but as the field increases the force increases to a maximum and then gradually diminishes. When the plates are near together and the condenser is charged negatively, a negative deflection is obtained, indicating that a current of air is then passing into the condenser. The difficulties experienced by several observers in their work on the motion of radio-active atoms in an electric field are undoubtedly due to the above phenomenon.

F. J. H.

928. *The Electrification of the Atmosphere, Natural and Artificial.* O. Lodge. (Inst. Elect. Engin., Journ. 52, pp. 833-844; Discussion, pp. 844-848; Appendix, pp. 848-852; March 2, 1914. Fifth Kelvin Lecture. Electrician, 72, pp. 892-895, March 6, 1914. Abstract.)—The first part of the paper contains a survey of the present position of our knowledge of atmospheric electricity and refers to the connection of Kelvin with this branch of science. The latter, as a result of his observations, formed the opinion expressed as follows: "The common fair-weather condition, I am forced to conclude, is due to a paramount influence of positive electricity in the higher regions of the air."

Lodge inclines to the same belief, and hopes that it may thus in the future be possible to effect some control over the weather by means of the electrification of the atmosphere. The main part of the paper is devoted to a consideration of the electrification of crops and its effect. A great deal of practical work has been done in this direction, and it has been proved that in many cases beneficial results may be expected from the treatment. It has been found that a suitable degree of electrification can be produced by a light network of wires supported on as few poles as one to the acre, and that a 2-h.p. engine will maintain the network at the necessary potential for a good-sized field, so that the expense of installing the plant is not unreasonably large. Voltages up to 100,000 have been employed in the experimental work. The results indicate that the most benefit is obtained in sunless years; that is, the electrification may be regarded as to some extent taking the place of sunshine. It also appears that the crops require plenty of water to obtain full benefit from the treatment. In the work done in the past the wire network has generally been charged so as to increase the intensity of the normal fine-weather potential gradient, but there is room for further experiment in the use of a strong negative gradient. The most complete experiments yet made are those carried out on wheat at Bevington, in Worcestershire. Over a period of 7 years an average increase of yield of over 25 % was recorded between the treated plot and the control plot. In seconding the vote of thanks to the lecturer, S. P. Thompson alluded to the great rapidity with which crops grow in the short summer of the Arctic regions, and suggested that the cause might be electrical and connected with the aurora borealis. An appendix to the paper contains a good deal of data bearing on the results already achieved in the application of electrical treatment to plants.

J. S. Di.

929. *Electric Charge of Rain.* J. Elster and H. Geitel. (Phys. Zeitschr. 14. pp. 1287-1292, Dec. 15, 1918.)—The authors put forward a modification of the influence theory of thunderstorms advanced by them in 1885. Instead of assuming a separation of a small drop from a larger one on the upper surface of the latter, they suppose it to take place at the lower surface. This implies that the potential gradient is opposite to the sign of the charges of the drops.

E. E. F.

930. *Electric Charge of Rain.* F. Schindelbauer. (Phys. Zeitschr. 14. pp. 1292-1296, Dec. 15, 1918.)—A reply to G. C. Simpson [Abstract No. 710 (1914)]. The author maintains that the theory ascribing atmospheric electricity solely to the disintegration of drops does not account for the electrification of snow, which shows phenomena not essentially different from ordinary thunderstorms. He prefers some kind of influence theory of thunderstorms.

E. E. F.

931. *Simultaneous Observations of Penetrating Atmospheric Radiation.* H. Benndorf, Dorno, Hess, v. Schweidler, and T. Wulf. (Phys. Zeitschr. 14. pp. 1141-1143; Discussion, pp. 1143-1144, Nov. 15, 1918. Paper read before the 85. Naturforscherversammlung, Wien.)—Simultaneous observations of the penetrating radiation in the atmosphere were taken in Graz, Davos, Vienna, Innsbruck, and Valkenburg (Holland) once a week for several weeks by means of Wulf's electrometer. In Vienna and Davos two instruments were used, which showed the same behaviour. But there was no connection between the indications at different places, which shows that the fluctuations are not of cosmic origin.

E. E. F.

DISCHARGE AND OSCILLATIONS.

932. *Flame Couples.* G. Moreau. (Comptes Rendus, 158. pp. 260-262, Jan. 26, 1914.)—Several substances, particularly chlorine and bromine, possess the property of modifying considerably the e.m.f. of flame couples. The series bare Pt—pure flame F_1 —pure flame F_2 —Pt covered with the oxide of an alkaline earth has an e.m.f., according to the oxide used, of from 0.55 to 0.70 volt, the electrodes being at 1400° abs. [see Abstract No. 517 (1914)]. If into the flame F_1 bromine water is sprayed, the e.m.f. increases with the concentration of the bromine in the flame up to a maximum which is about 0.55 volt higher than the initial value, which is regained as the flame becomes pure again. With chlorine, chloroform, and carbon tetrachloride similar effects are obtained. For the mixed series bare Pt—salted flame F_1 —pure flame F_2 —Pt covered with oxide [*loc. cit.*], analogous results are obtained on introducing the active substance into flame F_1 , the increase of e.m.f. in all cases being about 0.55 volt. The series cold Pt—pure flame—hot Pt has an e.m.f. of 0.55 volt, given by $E = I_p/e$, where I_p is the mean normal kinetic energy of a corpuscle of charge e leaving the hot Pt. The effect of the active substance introduced into the flame F_1 is to annul this e.m.f., and hence the e.m.f. of the flame couple is increased by the same amount. A. W.

933. *Ionisation by Positive Ions.* E[va] v. Bahr and J. Franck. (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 57-68, Jan. 15, 1914.)—It is known that positive ions with high velocities are strong ionising agents. Little is known, however, as to the ionising power of positive ions moving with small velocities, and conflicting estimates have been given for the value of the minimum voltage through which a positive ion has to fall in order that it may acquire a velocity sufficient for it to ionise molecules with which it collides. After discussing the work of Townsend and others upon the subject, the authors proceed to describe experiments similar to those on electrons by Franck and Herz [Abstract No. 659 (1913)] in which an attempt it made to ascertain the minimum voltage in the case of positive ions. As sources of these an incandescent Pt-wire, either bare or coated with aluminium phosphate, was used. This lay along the axis of a cylindrical Pt-cage. The positive ions were sent by means of an applied field through the surrounding cage into the annular space beyond, where they encountered a reverse field which sent them back to the cage. The ionisation produced in the annular space was measured by the current of negative ions passing through that space to an outer Pt-cylinder. The results obtained show, as was supposed, that positive ions are much weaker ionising agents, under these conditions, than electrons. No definite ionisation voltage can be given from the experimental curves, but if such exists it must lie both with air and with hydrogen below 6 volts, which is less than that for electrons. Various possible theoretical explanations are discussed, but owing to certain inherent difficulties as to the precise nature of the ions used, the velocity of emission of the ions, etc., the results must be taken as of a preliminary character only.

Further work is contemplated.

F. J. H.

934. *Ionisation by Heated Metals.* H. J. Proumen. (Bull. Soc. Chim. Belg. 27. pp. 295-300, 1918.)—Metals emit positive and negative ions when moderately heated (185° to 145° C.) in a dry atmosphere of filtered air, but there is a fatigue after some time which may last a long period. Measurement. VOL. XVII.—A.—1914.

ments were made with a Dolezalek electrometer. The experiments were made with an externally oxidised spiral of brass, with rusty nails, clean nails, and with other clean or tarnished metals. The amount of gas liberated was very variable. The gas, the author considers, is occluded in the surface layer or between the surface layer of oxide or sulphide and the metal underneath; when the gas-bubbles have found an outlet, no further fractures are produced by heating, and fatigue sets in. Ions may also be formed by slow oxidation and be occluded between the surface layer and the metal until liberated by heat. The chemical influence of surface layers is to be investigated. H. B.

935. Positive Ions from Hot Metals. O. W. Richardson. (Roy. Soc., Proc. Ser. A. 89. pp. 507-524, Feb. 2, 1914.)—Further experiments were made with the object of discovering the precise nature of the positive ions emitted from metals when they are first heated [see Abstracts Nos. 117 (1909), 118 (1911)]. Determinations of m/H , the electric atomic or equivalent weight, are carried out as before, but the apparatus is considerably modified in a number of details so as to ensure higher accuracy, since the earlier observations were not sufficiently exact to determine with certainty whether the ions are atoms of Na or K or are molecules of some of the commoner gases, such as CO, the electric equivalent of these substances not being widely different. With the modified form of apparatus either the slit or the balance method can be used simply by changing the connections outside the tube [Abstract No. 182 (1914)]. The results of a number of experiments with strips of Pt, iron, and manganin gave values of m/H very close to 40 during the first 86 hours of heating; after this values which fell fairly rapidly to about 24 were obtained. The value 40 is exactly the same to within the limits of experimental error as that obtained with a strip coated with K_2SO_4 , which has been previously shown by the author to emit positive K-ions [see Abstract No. 258 (1911)]. It thus appears that during the first stages of the heating, K-ions are emitted, after which an emission of Na-ions takes place. In the discussion of this result, the more important experimental observations which tend to support the view that the ions emitted are charged atoms or molecules of one or more of the commoner gases are enumerated and each dealt with in turn. Platinum strips treated in various ways were always found to give the same value of m/H , and the fact that putting the strip under mechanical strain causes the positive emission to be considerably increased leads the author to suggest that mechanical disturbance is in most cases the cause of the renewal of the emission after the metal has been glowed out and then subjected to some treatment or other. The author does not believe the question to be settled beyond the possibility of doubt, but the balance of evidence at present available favours the view that the emission from the various metals is due to the presence of potassium and sodium as common impurities. The amount of these present, however, according to an approximate calculation of the total emission is insufficient to be rendered evident by any chemical test. F. J. H.

936. Selective Action of Metals in the Photoelectric Effect. G. Reboul. (Comptes Rendus, 158. pp. 477-479, Feb. 16, 1914.)—Pohl and Pringsheim have shown that a selective photoelectric effect on metals exists. This selective action can be easily proved by the method described, and, at the same time, it is shown that the radiations producing the max. negative emission are those which the metal absorbs most easily. Use is made of the fact that an extremely thin layer of silver is transparent to ultra-violet light. The luminous

source used is a quartz mercury lamp. If the radiations most strongly absorbed are those which call forth by their incidence upon the lamina of silver the max. photoelectric emission, then the light after filtration should produce a relatively more feeble photoelectric effect with silver than with other metals. Experimental details are given, and the results obtained show that light filtered through silver always produces a relatively smaller effect with that metal. It is also shown that, except in the cases of Al and Zn, the series of metals calculated from Lindemann's formula is nearly identical with the series obtained by comparing the emission with a filtering lamina of transparent quartz with that obtained when using a silvered quartz filter.

A. E. G.

937. Discharge-tube Oscillograph. H. Greinacher. (Elektrotechn. Zeitschr. 85. pp. 212-213, Feb. 19, 1914.)—If two wires are arranged in a vertical plane in such a way that the distance between them is greater at the top than at the bottom, and are connected to a high-voltage transformer or to an induction coil, an arc is produced which, starting at the narrow end, travels up the wires. This phenomenon repeats itself indefinitely, the arc taking somewhere about a second to travel up the wires. The nature of the discharge is not revealed by a visual observation of this phenomenon. If, however, the wires are arranged in a vacuum tube, provided the gas pressure is suitable, the character of the discharge is beautifully demonstrated. A series of blue streamers, the cathode-glows, issue from each wire at regular intervals, these being interspaced by points of light which are the anode-glows. These tubes are thus self-contained oscillographs which, besides giving information respecting the character of the current, can also be used for a variety of quantitative purposes, such as the determination of the frequency of a current interrupter or, if run by an alternating current of known frequency, the measurement of the speed of a photographic shutter.

F. J. H.

938. Absorption of Light inside Quartz Mercury Lamps. F. P. Kerschbaum. (Zeitschr. Instrumentenk. 84. pp. 48-47, Feb., 1914. Electrician, 72. pp. 1074-1076, April 8, 1914.)—Discusses the absorption of the light from the (central) most luminous part of the discharge by the surrounding mercury-vapour, and describes a lamp in which the effect is reduced considerably. The lamp is water-cooled, and is provided with an electromagnet which is used to deflect the intenser part of the discharge to the wall of the tube. Thus an increased intensity of emission is obtained. A resonance lamp is also described, giving practically pure monochromatic light of wave-length $\lambda 2586$. [See also Abstract No. 1607 (1906).]

A. W.

939. Thermic Emission of Electrons and Photoelectric Effect of Potassium. K. Fredenhagen. (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 201-219, March 15, 1914.)—The author has previously developed the theory that the photoelectric effect with metals is in some manner dependent upon the presence of gas, and that metals, when entirely freed from gas, do not exhibit the normal photoelectric effect. Küstner's experiments with Zn [Abstract No. 717 (1914)] which were published at the same time seemed to give support to this theory. It is now shown that in the case of potassium the emission of electrons obtained by heating is not due to the K itself. Some agent, probably a gas, capable of bringing about this phenomenon exists and can be driven out of the metal or by other means put out of action. Several

methods of proving this point are dealt with. It is further shown that He, Ar, and N, cannot produce the effect. There appears to exist some connection between the emission of electrons due to heating K and its photoelectric behaviour, since both effects are diminished as the result of the same operations. It is shown that potassium can exhibit a photoelectric effect with and without temperature coefficients, according to the kind of treatment it undergoes. It would seem that the active agent both for the thermic and the photoelectric emission of electrons is hydrogen, but no direct proof of this is obtained. Further experiments are necessary before any definite conclusions as to the causes of the phenomena can be arrived at. A. E. G.

940. *Influence of Diameter upon the Potential-difference at the Terminals of Neon Tubes. Observations Relative to the Aurora Borealis.* G. Claude. (Comptes Rendus, 158. pp. 479-482, Feb. 16, 1914.)—It has been shown that with equal current density the fall of potential along the luminous column of neon tubes acting under a pressure of about 2 mm. Hg is practically inversely proportional to the diam. of the tube [Abstract No. 1994 (1918)]. In the present experiments the limits of operation are extended and the fall of potential at the extremities of the luminous column is measured directly instead of deducing the total p.d. as was formerly done. For this purpose the new tubes are furnished with large Pt-wires which penetrate to the luminous column and are placed at some cm. from the principal electrodes. The results represented graphically show that the fall of potential is approximately inversely proportional to the diam. A variation of pressure causes different effects in tubes of different diameters: thus, an increase of the pressure, 2.9 mm. usually employed, raises the p.d. in tubes of 67 mm. and 41 mm. diam. and reduces it in those of 10.7 and 5.6 mm. diam. It is found that the tube of 67 mm. diam. exhibited a fall less than that corresponding to its diameter. This is put forward in support of the argument, formerly given, that the fall of potential in tubes of very great diam. ought to be nil or very small. Should this be the case, it makes easier the comprehension of the phenomena of the aurora borealis. These are simply electric discharges of enormous section which, notwithstanding their great length, are produced without the existence of such infinite p.d.'s as would have been very difficult to conceive. A. E. G.

941. *The Striation of the Positive Glow Discharge in Hydrogen.* P. Neubert. (Ann. d. Physik, 42. 6. pp. 1454-1508, Dec. 28, 1918. Abridged Leipzig Dissertation.)—Investigations were made on the striated discharge in hydrogen, especially with a view to the more accurate determination of the ionisation pressure in H, and experiments with other gases were also undertaken; the influence of the cross-section of the tube on the constant mentioned was also examined. Careful measurements of the p.d. between successive striæ were made by means of observations of the p.d. between two sounds inserted in the vacuum tube, combined with measurements of the length of the striæ. The chief results obtained are as follows:—(1) A substantial influence of small traces of mercury on the p.d. between the striæ was proved. A diminution of as much as 88 % may be due to this cause. (2) The striation length in mercury-free hydrogen follows the law of Goldstein, $l = c \cdot r^{a-m}/p^m$, in which expression the constants $c = 1.9$ and $m = 0.522$ were accurately determined. (3) There occurs in hydrogen free from mercury with all pressures when there is sufficient current a constant striation p.d. of 11.9 to 12.1 volts. This is independent of the radius of the tube. (4) A new VOL. XVII.—A.—1914.

striation was observed which appeared with greater purity in the gas with cooling of the walls. In contrast to the usual blue it had a red colour with high pressures. The striæ are also much wider with high current strengths. It is first noticed at low pressures. (5) The striation-length of this decreases with falling pressure first of all from a high value, and then again increases. (6) The striation p.d. increases linearly from 12 volts at a pressure of 0.088 mm. to over 80 volts at 1 mm. pressure. When the discharge tube was cooled by liquid air similar curves were obtained. (7) Traces of oxygen, > 0.05 %, produced the usual blue striæ. (8) The potential gradient in the positive column experienced no sudden transition at the commencement of the striation. There is a simple relation between potential gradient and pressure for the striated and unstriated discharge, viz. $G = C \cdot p^m$, which affords as a consequence with constant striation-potential-difference the Goldstein law $l = a/p^m$. (9) The author expresses the view that the striation is a disturbance of the proper continuous positive column, due to the presence of traces of electro-negative gas. J. J. S.

942. Unidirectional Currents within a Carbon Filament Lamp. A. S. Eve. (Nature, 98. pp. 82-88, March 12, 1914.)—The type of lamp used has two large loops in the filament, with the middle of the loop fixed by a short wire fused in glass. If the terminals are earthed and a charged body, either positive or negative, is brought near the lamp, then the two loops diverge like two leaves of a simple electroscope. But if the lamp is lighted and a pointed rod, connected to a Wimshurst machine, gives a powerful positive discharge, the loops are not displaced, even if the point is close to the bulb. On the other hand, with a negative discharge, even a foot or two away, the two loops of the filament rapidly and repeatedly strike the glass and spring back. The action may be explained from the fact that the lamp acts like a valve, and that the current can only pass in one direction between the hot filament and the interior of the bulb. Further experiments are described confirming this view. F. L. Hopwood. (Ibid. p. 84, March 26, 1914.) A. W.

943. Ionisation in Unstriated Discharge and Arc. C. D. Child. (Phil. Mag. 27. pp. 277-288, Feb., 1914.)—A discussion on the electron theory of the above phenomena. It is concluded that the amount of light given by the unstriated discharge and by the arc indicates that the rate at which ions recombine in these forms of discharge varies as the *first* power of the current instead of as the *square*. This is explained by assuming that approximately all the current is carried by electrons and not by ions of molecular size. The fact that the electric force is a linear function of the gas pressure is also explained. [See Abstract No. 1781 (1904).] E. H. B.

944. Arc and Spark Discharge. A. Szarvassi. (Phys. Zeitschr. 14. pp. 1126-1127, Nov. 15, 1913.)—Paper read before the 85. Naturforscherversammlung, Wien. Ann. d. Physik, 42. 5. pp. 1081-1058, Dec. 2, 1913.)—Sketches a theory of arc and spark discharges on the basis of quasi-stationary currents. The theory is embodied in three differential equations of the first order, and this system of equations is called the "dynamical characteristic" of the discharge gap. The first equation determines the change in time of the conductivity of the gap due to self-deionisation and ionisation by the incandescent electrodes; the remaining equations give the change of temperature of the electrodes due to thermal conduction and Joulean heating. The electrode temperature is of little consequence in the case of the spark.

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The equations correctly represent Simon's arc hysteresis [Abstract No. 1465 (1906)]. It also shows how a d.c. arc which is naturally unstable may be steadied by a capacity in parallel.

E. E. F.

945. Photoelectric Emission of Electrons. R. Pohl and P. Pringsheim. (Phys. Zeitschr. 14. pp. 1112-1114; Discussion, pp. 1114, Nov. 15, 1918.)—Paper read before the 85. Naturforscherversamml., Wien.)—The normal photoelectric effect shows very large variations in the position of its long-wave limit. Thus, this limit is spontaneously displaced in a Ca-amalgam from $850\ \mu\mu$ to $600\ \mu\mu$. The cause of this displacement has not yet been found. The selective photo-effect is also strongly influenced by neighbouring bodies.

E. E. F.

946. Penetration, Deflection, and Interference of Refracted Electric Rays. G. Quincke. (Ann. d. Physik, 48. 3. pp. 337-392, Feb. 10, 1914.)—If a hollow metallic hemisphere is set on a thin electrophorus cake and from a positively or negatively charged Leyden jar a spark is passed to the hemisphere, then from the under edge of the hemisphere—the radiator—and normal to this edge positive or negative electric rays pass out. After dusting with flowers of sulphur and vermilion, the resin surface appears coloured yellow by positive electrical rays and red by negative rays. The penetration or distance reached by the rays increases with the electric potential of the inner coating of the jar.

Conducting and insulating prisms were used in the paths of the rays, the effects being shown in many tables and diagrams, reference to the original being necessary for the details.

E. H. B.

947. Refraction, Reflection, and Interference of Electric Rays. G. Quincke. (Ann. d. Physik, 48. 3. pp. 393-410, Feb. 10, 1914.)—A continuation of the work on electric dust-figures. [See preceding Abstract.]

E. H. B.

948. Loss of Energy and Ionisation produced by Kathode Rays. J. L. Glasson. (Roy. Soc. Tasmania, Proc. pp. 1-4, 1918.)—The experiments of the author and of W. Wilson have shown that over a considerable range of velocities the number of ions (α) produced by a kathode ray (or β -ray) in traversing unit length of air varies inversely as the square of the velocity (v) of the ray. Thus $\alpha = k/v^2$ and for air at atmospheric pressure $\alpha = 1140$ and $k = 2.5 \times 10^{22}$ [Abstract No. 60 (1912)]. Combining this result with Whiddington's absorption result $v_0^2 - v_x^2 = ax$, where $a = 2.0 \times 10^{40}$ [Abstract No. 558 (1912)], the author deduces that the kathode ray loses the same amount of energy per ion whatever its velocity may be, this energy corresponding to a fall through 110 volts. As the ionisation potential for air is only about 10 volts it follows that only a small fraction of the energy of the kathode or β -particle is spent in ionisation—a smaller fraction, in fact, than in α -ray ionisation.

E. M.

949. Measurements in the Electromagnetic Spectrum of Water with Slightly Damped Vibrations of 65 to 20 cm. Wave-length produced by Shock. A. R. Colley. (Ann. d. Physik, 48. 2. pp. 809-818, Jan. 23, 1914.)—The author replies to Rukop's criticisms [see Abstract No. 324 (1914)] of the methods of measurement employed by him.

T. H. P.

950. Damping of Hertzian Oscillators. G. Leimbach. (Phys. Zeitschr. 14. pp. 1226-1229, Dec. 1, 1913.)—Shows that it is possible to reduce the

damping in a simple or symmetrical antenna in a Marconi system by putting an auxiliary capacity in parallel with the spark-gap or within the gap, and using a quenched spark. [See also Abstracts Nos. 1486, 2001 (1918).]

E. E. F.

951. *Atmospheric Potential and Wireless Disturbances.* G. Lutze. (Phys. Zeitschr. 14. pp. 1148-1151; Discussion, p. 1151, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien. Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1100-1106, Nov. 15, 1918.)—The author used a new water-drop collector with combined pressure and suction spraying, and this, with a Wulf string electrometer, determined the atmospheric potential within 8 secs. By means of this instrument, very rapid changes in the atmospheric potential could be discovered. It was found that these changes are particularly rapid when the gradient itself is low. Moreover, they are often oscillatory and exhibit a high frequency. When that is the case, they give rise to "strays" in wireless receivers. Balloon trips made with this apparatus showed a great prevalence of these rapid changes inside clouds, especially the upper and lower cloud surfaces; but they gradually decrease as the height increases.

E. E. F.

952. *Propagation of Waves in Wireless Telegraphy.* G. Lutze. (Phys. Zeitschr. 14. pp. 1151-1158, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien. Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1107-1110, Nov. 15, 1918.)—Wireless signals from Norddeich and special signals from the Eiffel Tower were observed in free balloons at heights up to 6100 m. It was found that the Paris signals fell to one-eighth of their loudness in ascending from 1050 to 5500 m., Paris being 9° below the horizon at the latter height. The Norddeich signals fell to about half their intensity. The loudness was determined by the shunted telephone method. The experiments prove the existence of Sommerfeld's surface waves. The space waves are in the case of Paris intercepted by the horizon; hence the large decrease. Measurements of the influence of the distance between the stations upon the loudness show a decrement intermediate between the value for wet and the value for dry ground. The balloons used ascended from Bitterfeld.

E. E. F.

953. *Coupled Receiver in Wireless Telegraphy.* H. Riegger. (Jahrbuch d. Drahtlosen Telegraphie, 8. pp. 58-79, Jan., 1914.)—The paper is purely theoretical. It deals particularly with sharpness of resonance as regards current-effect in a coupled receiver. The incident wave is assumed to be of one frequency only. The decrements of the three waves may have any suitable values. The coupling is assumed to be extremely loose.

T. P. B.

954. *General Law of Magnetic Coupling.* F. Kiebitz. (Jahrbuch d. Drahtlosen Telegraphie, 8. pp. 45-57, Jan., 1914.)—The paper is purely mathematical. It gives an approximate solution of the cubic equation required to be solved for two magnetically coupled wireless telegraphy oscillation circuits. With an accuracy of 0.25% the approximate law of magnetic coupling is deduced, which gives the frequencies, amplitudes, phases, and damping-factors; δ being of the order of magnitude of the log. decrement of a circuit when not coupled. The paper also gives a new method of calculating the current-integral in the secondary circuit.

T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

955. *Absolute Measurements of Resistance.* F. E. Smith. (Roy. Soc., Phil. Trans. 214. pp. 27-108, March 19, 1914.)—The method adopted is one based on that of Lorenz. The instrument has 2 rotating discs and 4 magnetising coils instead of 1 disc and 1 coil as in the usual form of Lorenz apparatus. The magnetising coils are wound in single layers on marble cylinders, and the disposition of the coils with respect to the discs is such that the resulting magnetic fields through the discs are opposed in direction and the intensity of the field at points in the neighbourhood of the edge of a disc is of zero value, or nearly so. Each of the two discs supports 10 insulated phosphor-bronze segments placed at equal distances around its circumference, and the 10 segments on one disc are connected to those on the other disc by 10 conducting wires passing through the centre of the shaft. When the wires rotate with the discs a difference of potential is produced between their ends. The 10 conductors are treated as 5 sets of two, and the 5 sets are at times placed in series by means of 10 brushes (5 to each disc), and at other times they are placed in parallel. The difference of potential produced by rotation is balanced against that on a standard resistance R through which the same current flows as through the coils. The resistance R is thus found in terms of the rate of rotation of the conductors and the mutual inductance of the coils and brush contact circles. The resistances measured had nominal values of 0.001 ohm, 0.002 ohm, and 0.01 ohm. The observed values in absolute measure and the values in International ohms, are given in the following table:—

No. of Observations		Resistance.			Difference, parts in 100,000 (Abs. $\times 10^{-9}$) - (Int.).
		Standard.	Absolute Measure, cm./sec.	In International Ohms,	
28		0.001 ohm	100091 ₄	0.00100089 ₉	52 ₉
12		0.01 „	100090 ₁₀	0.0100088 ₉	51 ₈
5		0.002 „	Standard resistance varied		53 ₀
2	{ Coils 1 and 2 used	0.001 „	100090 ₄	0.00100089 ₉	51 ₁
2	{ Coils 3 and 4 used	0.001 „	100091 ₈	0.00100089 ₉	52 ₉

The conclusion is that a resistance of 1 International ohm is equal to 1.00052 ± 0.00004 ohm (10^9 cm./sec.⁻¹), the probable error of ± 0.00004 being the sum of those involved in the realisation of the ohm and the International ohm. It follows that a column of mercury at 0° C., 108.245 \pm 0.004 cm. long, of constant cross-sectional area (the same as that of the International ohm), has a resistance of 1 ohm. The mass of this column will be 14.4446 ± 0.0006 gm

F. E. S.

956. *Thermo-electromotive-force.* C. Dannecker. (Ann. d. Physik, 42. 6. pp. 1504-1580, Dec. 28, 1918.)—The occurrence of a double neutral point in the e.m.f. of certain thermo-elements has been investigated by the author between the limits of temperature -200° and $+1000^{\circ}$ C. The method of comparison of e.m.f.'s used was a compensation one similar to that employed by Chassigny, Abraham and Noll, a moving-coil galvanometer being used as

a null instrument. The occurrence of a double neutral point was shown in the case of the following junctions: Co-Ni, cobalt-German silver and cobalt-nickelin. The approximate course of the curves connecting e.m.f. and temperature was determined in the case of the thermo-elements: Nickel-German silver, cobalt-nickel iron, nickel-nickel iron, constantan-nickel, nickel-nickelin, constantan-cobalt, aluminium bronze-iron, and cobalt-iron, between the temperatures -200° and 1000° . These are given in tables and diagrams. Confirmation was obtained of the remarkable course of the e.m.f. curve of iron-nickel iron as described by Barrett, of nickel-iron (Harrison) and of copper-cobalt (Pécheux). A division was made of the curves obtained into definite groups which the connection between the e.m.f. and the materials of the thermo-elements easily allows to be perceived.

J. J. S.

957. Peltier-effect at High Temperatures. P. Cermak. (Phys. Zeitschr. 14. pp. 1178-1179, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien. Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1168-1164, Nov. 15, 1918.)—The Peltier-effect is made visible by means of an iron wire and a constantan wire soldered end to end with gold, so as to make apparently a single wire. This is suspended in a glass vacuum tube, and a block of Cu is attached to the lower end, where it dips into mercury to make a contact. On sending a current of some 5 amps. through the wire, the junction either glows more brightly than the rest or remains dark, according to the direction of the current. The effect may also be shown by welding a Pt-wire 0.8 mm. thick to a 40 % Pt-Rh wire, and it may then be shown by projection, although not so distinct as in the iron-constantan combination. A somewhat similar effect may be seen in the thickened end of a Nernst filament.

E. E. F.

958. Electrification at Liquid-gas Surfaces. H. A. McTaggart. (Phil. Mag. 27. pp. 297-314, Feb., 1914.)—A rotating cell method of examining the electric charges on small spheres of gas in a liquid has been devised. Confirmation is obtained of Quincke's observation that in distilled water through which an electric current is passing, small bubbles of air, oxygen or hydrogen move towards the positive pole (Pogg. Ann., 118. p. 518, 1861). The velocity of small gas spheres in water is found to be proportional to the potential gradient and, within limits, independent of their size. For bubbles of air, oxygen and hydrogen in water, the velocity is found to be about 4×10^{-4} cm. per sec. per volt per cm. Dissolved salts affect the charge at a gas-liquid surface, the activity of the salt depending on the charge carried by its ions in solution. In absence of polyvalent ions, an air-water surface is electrically neutral in a slightly acid solution. A sphere of gas in a solution can change the sign of its charge as it diminishes in size owing to its absorption into the solution. Under the conditions of the author's experiments, the electric charge at a liquid-gas surface appears to be almost independent of the nature of the gas.

T. H. P.

959. Measurement of Electric Potentials at a Distance without Wires. B. Szilard. (Comptes Rendus, 158. pp. 561-564, Feb. 23, 1914.)—In strongly ionising the air between an electrically charged body and an insulated conductor at the potential of the earth, a passage of charge takes place and the lines of force undergo a modification. It follows that the insulated conductor is raised to a real potential, higher than that corresponding to the value of the

field, at that distance, in air which is not ionised. A disc furnished with a strongly radio-active substance serves at the same time as ionising source and means of estimating the potential. This arrangement, placed upon an insulated support, is connected to a direct-reading electrometer which indicates the voltage. A list of experiments which can be tried with the apparatus sketched is given. The method described can be applied to the measurement of high electric pressures from a distance without any contact with the conductor. It is also of use for measuring the electrification of insulators and rotating bodies with which it is not possible to establish electric contact.

A. E. G.

960. *Electric Double Layers on Metals in a Vacuum.* R. Seeliger. (Phys. Zeitschr. 14. pp. 1287-1288; Discussion, p. 1288, Dec. 1, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—In measurements of the specific charge of electrons, etc., many errors are introduced by the formation of electric double layers on electrodes and neighbouring metallic surfaces. These can be entirely eliminated by kathode sputtering from the material to be cleaned. The sputtering should be repeated before each important measurement, as the immunity lasts only a few minutes. Platinum is preferable.

E. E. F.

961. *Electric Conduction in Metals.* F. Skaupy. (Deutsch. Phys. Gesell., Verh. 16. 8. pp. 156-167, Feb. 15, 1914.)—Discusses under certain assumptions the electric conduction in liquid mercury; liquid amalgams; diffusion phenomena; dissociation of liquid mercury; also the case of solid metals. [See Abstract No. 1898 (1907).]

E. H. B.

962. *Inaccuracy of a Copper Voltmeter.* N. Dhar. (Zeitschr. Elektrochem. 19. pp. 746-748, Oct. 1, 1918.)—Like Richards and others the author finds by coupling a copper voltmeter in series with a silver voltmeter, that the copper voltmeter is not reliable for weak currents (0.5 to 5 milliamps.), and that the various researches by different workers do not explain why the results are generally far too low.

H. B.

963. *Radium Measurements by the γ -Ray Method.* V. F. Hess. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1002-1016, Oct. 80, 1918. Paper read before the 85. Naturforscherversamml., Wien. Phys. Zeitschr. 14. pp. 1135-1141, Nov. 15, 1918.)—Wulf's double-fibre string electrometer may be used for the measurement of the strength of Ra or mesothorium preparations by means of the ionisation produced within the electrometer case by the γ -rays of the preparation when placed at a certain distance (say, 1 m. for 80 mgm. metallic Ra) from the preparation. When the capacity and sensitiveness of the electrometer are accurately known, the Ra measurement may be made an absolute one with the knowledge of the ionising power of γ -rays and the amount of γ -rays emitted by a given quantity of Ra. The absolute measurement thus made is liable to errors of 2 or 3 per cent. Comparisons with standard preparations may be made to within $\frac{1}{2}$ per cent. The sensitiveness preferred is 4 volts per division. The wall of the case consists of brass 8 mm. thick. The author also describes a method not involving a time measurement. It employs a single-fibre electrometer, with the ionisation chamber earthed through a xylol resistance and connected to the fibre. The deflection of the fibre is accurately proportioned to the ionisation.

E. E. F.

964. Apparatus for Radio-active Measurement. B. Szilard. (Archives d'Él. Médicale, 22. pp. 28-33, Jan. 10, 1914.)—A rigid needle provided with a spiral spring moves over a fixed scale, being attracted by a charged sector. The rate of movement over the scale measures the loss of charge and by connecting up to suitable ionisation chambers any kind of radio-active measurement can be made by direct observations without telescope, etc. Activities of the order of 1/100 the α -ray activity of uranium oxide can be measured. E. M.

965. Theory of the String Galvanometer. R. Förster. (Elektrotechn. Zeitschr. 35. pp. 146-149, Feb. 5, 1914.)—A mathematical paper on the string galvanometer, in which the author obtains from the equations of motion of the string, the forms of motion of the string with and without air damping, and the connection between the sensitiveness and the frequency when a sinusoidal current is passed through the string. The results so obtained are compared with experimental data. For further particulars the original should be consulted. W. C. S. P.

966. Sensitive Photoelectric Cell. A. L. Hughes. (Phil. Mag. 25. pp. 679-682, 1918.)—Constructional details of a sensitive cell for which very great sensitiveness is claimed are given. Only a very small amount of metal (K, Na, Rb, Cs) is required. In the case of the last two this is of some importance owing to their expensiveness. L. H. W.

967. Continuous-current Galvanometer instead of Telephone as Zero Instrument in Alternating-current Measurements. G. Pfeiderer. (Zeitschr. Elektrochem. 19. pp. 925-931, Dec. 1, 1918.)—The author takes alternating-current measurements by means of a continuous-current galvanometer, used as zero instrument, by inserting in the zero-lead of the bridge an auxiliary interrupter which oscillates in synchronism with the automatic interrupter of the induction apparatus and is of similar construction (band spring). This insertion introduces a certain asymmetry into the bridge; but the theoretical and experimental investigations show that the average error is about the same for the new method and the telephone method, even when the polarisation causes an error of nearly 1 per cent. The disadvantage of the new method is that asymmetries and errors are less readily noticed than with the telephone; the advantages are the absence of noise, greater convenience, and decidedly greater sensibility, and the possibility of making use of precision rheostats. H. B.

968. Electrical Foam Walls. G. Quincke. (Ann. d. Physik, 48. 8. pp. 411-460, Feb. 10, 1918.)—A discussion of the electrical nature of the partitions of the foam or froth cells in oily or soapy compounds. E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

969. Apparatus for the General Cryomagnetic Investigation of Substances of Small Permeability. H. K. Onnes and A. Perrier. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 689-699, Jan. 29, and pp. 786-789, Feb. 26, 1914. Communication No. 189a from the Phys. Lab., Leiden.)—The construction of the apparatus described forms part of a more general scheme gradually to obtain the necessary appliances for the investigation of weak magnetisation at low temperature [see also Abstract No. 168 (1914)]. It is suitable for cylindrical specimens and may, without important change, be

adapted to the study of small objects placed at the point of maximum attraction; it can also be used for liquids. The magnetic attraction or repulsion on the specimen is caused to act along the vertical, and is measured by compensating it by means of the electromagnetic attraction of two coaxial coils. The specimen is attached to a carrier which can move vertically in an air-tight enclosure between the poles of the electromagnet which supplies the applied force. The weight of the carrier is balanced by two floats immersed in mercury. Details of the working of the apparatus are then given, a relative accuracy of about $\frac{1}{4}$ per cent. being obtained in susceptibility measurements.

G. E. A.

970. *Extension of Thomson's Theory for the Constitution of Magnets* by Vaschy's Method. J. B. Pomey. (Journ. de Physique, 4. Ser. 5. pp. 126-184, Feb., 1914.)—According to Thomson's theory, each volume element $d\bar{w}$ of a magnet is supposed to be an elementary magnet of moment $I d\bar{w}$ made up of two equal masses of contrary sign of an imaginary fluid obeying Coulomb's law. The potential V is then equal to $-\int \left(I, \text{grad} \frac{1}{r} \right) d\bar{w}$, the integral being extended throughout the volume V of the magnet. The bracket represents the scalar product: $-A \partial \frac{1}{r} / \partial x - B \partial \frac{1}{r} / \partial y - C \partial \frac{1}{r} / \partial z$ where A , B , and C are components of I . From this is deduced the expression $V = -\int \frac{\text{div } I}{r} d\bar{w} - \int \frac{(I \nu_s)}{r} ds$, the surface integral being taken over the surface of the magnet. $I \nu_s$ represents the scalar product of I by the unit vector ν_s normal to ds and directed towards the interior of the magnet. The object of the present note is to establish this second potential formula by mathematical reasoning based on Coulomb's experiments and on the behaviour of a broken magnet without recourse either to an imaginary fluid or to action at a distance.

H. H. Ho.

971. *Effects related to the Hall-effect.* E. P. Adams. (Phil. Mag. 27. pp. 244-252, Feb., 1914.)—Investigates the Corbino effects on the electron theory and discusses their relation to or identity with the Hall-effect. [See Abstract No. 1597 (1911).]

E. H. B.

972. *The Diurnal Variation of Terrestrial Magnetism.* G. W. Walker. (Roy. Soc., Proc. Ser. A. 89. pp. 879-892, Jan. 1, 1914.)—Schuster has made a most inspiring and systematic attempt to reduce the observational matter obtained at various observations to scientific law and order. In departing from the method pursued by him, this change of procedure was in no small degree suggested by various remarks in Schuster's memoirs. When the instruments at Eskdalemuir Observatory were so arranged as to record directly the geographical components of magnetic force, and the tabulated results for 1911 took definite shape the results were compared by the author with those of the only other observatory which at the time also recorded those components, namely Potsdam (Seddin). The comparison brought out points of interest and induced the author to collect data from other observatories as to the deduced values for the geographical components.

Following Schuster, the desired data were the Fourier coefficients in the geographical components. Investigation was confined to the 24-hour and the 12-hour terms, for it is realised that the errors which arise on the experimental and observational side, render the shorter-period terms of very doubtful

accuracy. Attention was further confined to the average yearly value, not because the seasonal variation is unimportant but to avoid error in dealing with a multitude of facts. The data obtained from Pavlovsk, Eskdalemuir, Wilhelmshaver, Potsdam, De Bilt, Pola, Helwan, Bombay, and Batavia are given in tabular form. It is stated that : (1) Practically all days are used, not selected quiet days. (2) The original curves are not smoothed, except in the case of the V results for Pola. (8) The original curves gave records of H and D except at Eskdalemuir and Seddin, where N and W were directly recorded. (4) The hourly values are those at the exact hour, except at Seddin, where the hourly value is the estimated mean for an hour centring at the exact hour. It is desirable that data should be obtained precisely in the same way, and before entering on a minute arithmetical computation, all data should refer to the same year. But it became obvious to the author that it would be necessary to wait several years before such data could be obtained. Still broad inferences may be drawn from the data collected in the table which seem of vital importance. If, according to Schuster, it is correct to represent the variations by a potential function the problem may be divided into two parts :—(1) The empirical determination of the potential function which represents the observations. (2) The theoretical investigation of the physical causes that give the potential function so determined. For the computations entered upon by the author reference should be made to the original paper. He remarks that a simple specification has been formed of the terms which seem to fit with the data. He has no theory to propose as to their origin, beyond Schuster's view that they arise from differential conductivity of the upper regions of the atmosphere. If further data confirm the probable reality of the terms, it should not be a difficult matter to express the law of conductivity which would account for them. As we have only had to proceed to second differentials with regard to the sun's direction, or the earth's way, it does not look as if the differential conductivity required is of a very complex nature.

The possibility of associating the electric and magnetic state of the earth with its translational movement has often attracted attention although without success. There follows a general solution of the electro-magnetic equations for a body of conductivity C moving in a straight line with velocity KC , where C is the velocity of radiation.

E. O. W.

973. Propagation Velocity of Magnetic Disturbances and Pulsations. *Report on Records of Terrestrial Magnetic Disturbances made at Apia (Samoa), Batavia, Chellenham, and Tsingtau for September, 1911.* G. Angenheister. (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 4. pp. 565-581, 1918.)—The object of the present paper was to obtain data for the study of magnetic disturbances and pulsations, by means of a system of rapid registration which allowed movements recorded at distant stations to be identified with certainty. Previously van Bemmelen, from a comparison of similar observations, came to the conclusion that the registered pulsations were not simultaneous, although the differences are only very slight. Also K. Birkeland of the Norwegian Aurora Polaris Expedition, 1902-8, opined that the difference between the incident times at the various observatories was too small to be detected by the mode of registration adopted. From a comparison of 88 disturbances between the years 1888-1908, L. A. Bauer arrived at an opposite result to Birkeland, finding the disturbance to be propagated with a measurable velocity round the earth, the average time for a complete revolution either eastwards or westwards being about 7 minutes. In Dec., 1910, the Depart-

ment of Terrestrial Magnetism of the Carnegie Institution requested every observatory to furnish particulars on the incident phases of the 15 most remarkable disturbances between the years 1906-1909. From the response made by 82 observatories the present paper dealing with the propagation velocity owes its existence. The author groups the 82 stations according to their geographical longitude into 4 divisions, and gives tables of data arranged according to this classification. He has also submitted the 17 cases of Bauer to the same exact analysis as the present series, numerous curves and tables being given. As a general conclusion, the author states it to be highly probable that the time-differences between separate groups do not constitute a measure for the determination of disturbance velocities but rather of observation errors. It is open to doubt whether it will be possible to determine velocity propagation from disturbance incidence, since this depends not only on the efficiency of registration but also upon the certainty of identifying definite phases at different stations. The author also believes he has established that the time-difference between pulsations at different observatories is smaller than that given by the records—a fact of great importance for the physical significance of these magnetic phenomena. Since for large distances the pulsations succeed practically simultaneously, the author believes them capable of utilisation for the determination of geographical longitude.

H. H. Ho.

RADIOLOGY AND ELECTROPHYSIOLOGY.

974. Elimination of Secondary Radiations produced in a Radiographed Object. G. Bucky. (*Archives d'Él. Médicale*, 22. pp. 92-95, Jan. 25, 1914.)—Röntgen rays produce two kinds of secondary rays: one which arises in the walls of the tube, the other in the object radiographed. The quality of a radiograph depends, in the first place, on the absence of these secondary rays. A screen is described and photographs are given showing the effect the screen has on preventing the secondary radiation from acting upon the radiograph. It is believed that this screen will be particularly useful when radiographs of soft parts are required. The image of the screen appears on the plate as a system of squares. While this may not be without advantage in certain cases in which it is desired to measure some organ, yet, in other instances, it would be somewhat of a hindrance. Further experiments are in progress to see if the image of the screen can be eliminated. A. E. G.

975. Correct Optical Valuation of Modifications of the Colour of Radio-dosemeters. G. Bucky. (*Archives d'Él. Médicale*, 22. pp. 189-148, Feb. 10, 1914.)—Many radio-dosemeters utilise the modification of the colour of certain chemical substances, when subjected to the action of Röntgen rays, as a measure of the dose of the applied rays. For that purpose pastilles of different colours, the shade of which is determined empirically, are compared with a pastille on which the radiation has acted. There is thus always the great difficulty of judging which colours nearest approach each other in shade. Further, the luminous source available when making the comparison plays an important part in the estimation. It is claimed that the method now described removes these difficulties and has the following advantages:—The dose can be read with optical exactness, by means of a constant luminous source, other causes of optical errors being also removed. It facilitates the estimation by transforming a comparison of colours into a comparison of brightness. The estimation can be made during the time the radiation is in

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action, there being no need to remove the pastille from the tube. The fractional doses can be determined with an exactitude of 1 to 2x. The diminution of tint is avoided, since the pastille is completely protected from daylight during the action of the radiation and also during the comparison.

A. E. G.

976. *Comparison of Scales of Hardness and Quantimeters.* (Archives d'Él. Médicale, 22. pp. lx., Feb. 10, 1914.)—The following tables indicate the concordance of the principal notations.

I.—SCALES OF HARDNESS OF RAYS.

Benoist.	Benoist-Walter.	Wehnelt.	Walter.
Degrees B.	Degrees B—W.	Degrees Wh.	Degrees W.
2	1	About. 1·8 to 2	2 to 3
3	2 to 3	5	4 to 5
4	4	6½	5 to 6
5	4½	7½	6
6	5	8	6 to 7
7	5½	9	7
8	6	10 to 11	7 to 8

II.—QUANTITOMETERS AND QUANTITOMETRIC UNITS.

Chromo- radiometer Holznecht.	Radiometer Sabouraud- Noiré.	Chromo- radiometer Bordier.	Units. Bordier Galimard.	Fluorimetric Quantimeter Guillemot.	Quantimeter Klenböck.	Fällungs- radiometer. Schwartz.
Units H.	Tints.	Tints.	Units I.	Units M.	Units X.	Kaloms.
1 H	Tint B			125 M	2 X	
1½ H				187 M	3 X	1 Kalom
3 H		Tint O	1·8 I	375 M	6 X	2 Kaloms
4 H		Tint O to I	2 to 3 I	500 M	8 X	
5 H		Tint I	3 to 4 I	625 M	10 X	3·5 Kaloms
6 H		Tint I to II	4 to 5 I	750 M	12 X	
7 to 8 H		Tint II	5 to 6 I	865 to 1000 M	14 to 16 X	
14 H		Tint III	10 I	1750 M	28 X	
20 to 22 H		Tint IV	15 I	2600 M about	40 to 44 X	

The items in heavy type show the connections between the scales.

A. E. G.

977. *"Villard" Vacuum Tubes.* (Brit. Pat. 29,889 of 1912. Elect. Engineering, 10. p. 69, Jan. 29, 1914. Abstract.)—In the arrangement due to E. W. Caldwell the kathode is arranged to cause sufficient concentration of the kathode stream under abnormal regulating conditions to introduce or generate gas in the tube and to restore it automatically to its normal condition. A large surface kathode, a small focusing member, and a loosely movable spherical mirror concentrate the heat of the kathode to effect the regulation.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

978. Modified Hittorf Model for Demonstrating the Migration of the Ions. **F. Weigert.** (*Zeitschr. Electrochem.* 19. pp. 886-887, Nov. 15, 1918.)—The model illustrates in particular the electrolysis of cupri- and cupro-salts, with soluble and insoluble electrodes, with the aid of sliding metal plates and coloured glasses (white, blue, green, red). H. B.

979. Active Nitrogen. **E. Tiede and E. Domcke.** (*Ber. Deutsch. Chem. Gesell.* 46. 17. pp. 4095-4108, Dec. 29, 1918, and 47. 2. pp. 420-426, Feb. 7, 1914.)—The authors adhere to their statement that certain phenomena, which had been ascribed to active nitrogen, are not observed when pure nitrogen is used, but make their appearance when oxygen is introduced. Active oxygen alone is capable of producing some of these phenomena. They fail to confirm Strutt as to experiments with iodine, sulphur, sodium, and thallium chloride. The afterglow of the nitrogen becomes weaker and finally disappears as the nitrogen is more and more purified of oxygen by being passed over heated copper; care must, however, be taken not to heat the copper above the dissociation point of copper oxide, otherwise the glow will appear. **F. Fischer** (*Ibid.* 46. 17. p. 4108, Dec. 29, 1918) agrees with Tiede and Domcke. **H. B. Baker and R. J. Strutt.** (*Nature*, 92. p. 659, Feb. 12, 1914.)—Repeating Tiede and Domcke's experiments with barium or potassium azide, the authors do observe the questioned afterglow. They also find it when the discharge bulb is filled with the liquid alloy of potassium and sodium and with rarefied nitrogen; the surface of this alloy was still bright after several weeks, and the afterglow as distinct as before. They ask, moreover, which gas—if not active nitrogen—could effect the reduction of hydrocarbons to hydrocyanic acid observed by Strutt. **A. Koenig and E. Elöd.** (*Ber. Deut. Chem. Gesell.* 46. 18. pp. 2998-3009 1918, and 47. 8. pp. 528-580, Feb. 21, 1914.)—The authors criticise Fischer and Hene and confirm Strutt and Baker. If Tiede and Domcke had analysed their gases spectroscopically they would have noticed that the gases contain mercury-vapour; this vapour destroys the afterglow because the mercury at once combines with the active nitrogen to nitride, momentarily showing the greenish mercury luminescence, as the authors together with E. Szöllösi observed (research not yet published). **H. B. Baker and R. J. Strutt.** (*Nature*, 98. p. 5. March 5, 1914.)—Again repeating the new experiments of Tiede and Domcke with regard to the elimination of any trace of oxygen by heating finest gauze of copper slowly from 15° up to 480° C., the authors do not observe any distinct change in the intensity of the afterglow. The statement by Tiede and Domcke, that active oxygen could alone produce the characteristic effects of active nitrogen, altogether fails to account for the formation of hydrocyanic acid which Tiede and Domcke do not dispute.

H. B.

980. Decomposition of Highly-complex Chemical Compounds in Varying Magnetic Fields. **G. W. Heimrod.** (*Zeitschr. Elektrochem.* 19. pp. 812-816, Oct. 15, 1918.)—Experiments made in Hanover on behalf of the Rockefeller Institute for Medical Research of New York do not confirm the communication addressed to the Berlin Academy by I. Rosenthal [Abstract No. 689 VOL. XVII.—A.—1914.

(1908)], which R. Cegielskij had already questioned. Solution of starch, 2.5 per cent., was placed within a solenoid through which alternating currents of about 450 (200 to 900) cycles per sec., produced with the aid of a Wehnelt interrupter, were sent for several days, the temperature of the solution being raised up to 90° C.; a water-jacket was interposed as the coil became very hot. A very slight inversion was sometimes observed; but it was practically the same within and without the magnetic field, also in the presence of an electrolyte, NaCl, HCl, H₃PO₄, and of diastase. H. B.

981. *Curious Atomic Weight Relations.* F. H. Loring. (Chem. News, 108. p. 247, Nov. 21, 1918.)—The author regards the discovery of gallium in commercial Al by Boulanger and Bardet (Comptes Rendus, 157. p. 718, 1918) as related to Thomson's observation of a very faint line, corresponding with an atomic weight of about 85, on the plate showing the strongest He line [Abstract No. 1862 (1918)]. If gallium is widely distributed in nature its presence in a vacuum tube is not strange, and as this metal has physical properties closely resembling those of mercury, it might carry a double charge and consequently have an atomic weight of half 70. Gallium does not fall into line with the other elements in the author's scheme [see Abstract No. 1112 (1909)], and, from the tabular arrangement given, it should apparently fall on the curve with bromine. This would entail a value of 71.87, which would find a place in the extension of the author's scheme [see Abstract No. 294 (1910)], and this value (taken as 71.88), together with the fact that the element is related to thallium, renders possible the series:

	Differences.		
H 1.01			
	7.89		
Be 8.90		18.66 (b)	2a = b and a + b = 28.
	26.55		
Cl 35.45		9.88 (a)	
	85.88		
Ga 71.88			

T. H. P.

982. *Valency of Radio-active Elements.* G. v. Hevesy. (Phys. Zeitschr. 14. pp. 1202-1209, Dec. 1, 1918.)—The valencies of fifteen radio-active bodies were determined by means of their diffusion in acid solutions. The valencies thus formed agree without exception with those derived from the general chemical character of the elements. Actinium gives trivalent ions, which supports the view that it is the missing homologue of lanthanum. In alkaline solutions the disintegration products of the emanations are present in a colloidal state, as supposed by Paneth and Godlewski. Polonium is colloidal in neutral and feebly acid solutions. The colloid particles contain sometimes only two or three atoms. E. E. F.

983. *Theory of Polymorphism.* G. Tammann. (Phys. Zeitschr. 14. pp. 1087-1098; Discussion, p. 1098, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—Assumes that molecules in the process of crystallisation become anisotropic and take up the relative positions demanded by this structure. Certain molecules can be anisotropic in various directions, and this gives rise to polymorphism. This view is illustrated by the crystallisation of water. E. E. F.

984. *Structure of Diamond.* L. Föppl. (Phys. Zeitschr. 15. pp. 191-198, Feb. 15, 1914.)—Discusses the fundamental form on which the structure of the diamond is based. [See also Abstract No. 1778 (1918)]. A. W.

985. Preliminary Report on Uranium, Radium, and Vanadium. R. B. Moore and K. L. Kithil. (Bureau of Mines, Bull. 70. [97 pp.] 1918.)—The bulletin presents a summary of available information regarding the sources of uranium, radium and vanadium, the methods used in treating the ores, and the uses of the finished products. In particular the paper describes the ores found in the United States, giving especial attention to those characteristics of the ore and the conditions of their occurrence that affect mining and treatment. E. M.

986. The Allotropy of Copper. E. Cohen and W. D. Helderman. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 628–682, Jan. 29, 1914.)—Electrolytic copper has been cast into ingots and quenched in water immediately after solidification. Determinations of the density of turnings indicated an increase from 8.89 to 8.90 after heating for 24 hours at 100° C. Subsequent dilatometric experiments showed that copper undergoes an allotropic change at 71.7° C. In solid metal the change is remarkably slow but the rate can be accelerated by the use of fine turnings or by boiling in a solution of an electrolyte such as copper sulphate solution. F. C. A. H. L.

987. The Metastability of Metals in Consequence of Allotropy and Its Significance for Chemistry, Physics and Technics. E. Cohen. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 682–684, Jan. 29, 1914.)—The author points out that, in view of the latest work on the allotropy of metals formerly thought to be capable of existence in only one form [see preceding Abstract], it will be desirable to redetermine the various physical constants in the stable systems, since the existing values have been determined in metastable systems containing unknown proportions of the α and β modifications. F. C. A. H. L.

988. Ascending and Descending Cold Work. Hanriot and Lahure. (Comptes Rendus, 158. pp. 404–406, Feb. 9, 1914.)—Cold work and annealing affect the various mechanical properties of metals in such a manner that one is justified in asking if the two are interdependent. A metal can be mechanically hardened to a predetermined degree (as measured by ball hardness) either by direct cold work or by subjecting the metal to the max. amount of cold work it will stand followed by suitable annealing. The first process is described as “ascending cold work” and the second process as “descending cold work.” Tensile tests carried out on silver and brass cold-worked by both processes show that for equal degrees of hardness the tensile strengths of the “ascending” specimens are less, and the elongations greater, than the corresponding properties of the descending specimens. It has also been shown that subsequent cold work to rupture invariably produces a greater degree of hardness in the descending samples. Annealing at constant temperature produces, in the early stages, a more rapid fall of the hardness of the specimens cold-worked by the descending method than in those treated by the ascending process. Ultimately, however, a limiting value is reached which is the same for both varieties. In every case the variations in the partially annealed samples are more regular than those observed in the directly hardened samples. F. C. A. H. L.

989. Minimum Temperature of Annealing. Hanriot and Lahure. (Comptes Rendus, 158. pp. 262–264, Jan. 26, 1914.)—Experiments have been made to determine the lowest temperature at which annealing of plates of silver (cold-hardened to different extents) takes place, by noting their ball
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hardness numbers after 4 hours' heating at the particular temperature. The results show that the annealing temperature decreases as the degree of cold working increases. In severely strained material annealing is very rapid after it has once set in, so that the hardness soon falls below that of a plate less severely worked. Experiments carried out on silver and zinc over prolonged periods of time showed that annealing is slow at low temperatures. A plate of zinc showed no effect after 8 hours at 78° C. but a considerable decrease had occurred after 18 hours. More prolonged heating (15 hours) did not affect the results.

F. C. A. H. L.

990. Weldability of Metals and Alloys. R. Amedeo. (Rev. de Soudure Autogène IV. p. 462, 1912. Rev. de Métallurgie, 11. pp. 57-58, Jan., 1914. Extract.)—The welding power of alloys is intimately bound up with the phenomena which immediately precede and accompany fusion, and an examination of the liquidus and solidus of alloys enables limits to be fixed between which such materials will weld readily. For this purpose the temperature-difference between liquidus and solidus should not be great, as this permits of penetration of oxygen and resultant burning of the metal. In the iron-carbon series alloys containing up to 0.5 % carbon can be welded readily; between 0.55 and 0.8 % carbon welding can be effected with difficulty and with considerable danger of burning, while the alloys containing about 2 % carbon present the greatest difficulty in welding. Alloys with 4 % carbon can be welded readily. In every case it is necessary to anneal after welding and in the case of the 0.65 to 0.8 % alloys it is advisable to quench first and then anneal. In brasses, alloys in the neighbourhood of 65 % Cu and 35 % Zn show the greatest welding power.

F. C. A. H. L.

991. Recrystallisation of Cold-worked Zinc. G. Timofeeff. (Rev. de Métallurgie, 11. pp. 127-182, Jan., 1914.)—A study has been made of the relationship existing between the microstructure of zinc and the mechanical and thermal treatments to which it has been subjected. The best etching agent for Zn has been found to be a few drops of a solution containing 94 % strong nitric acid and 6 % chromic acid in 100 c.cm. of water. Cast metal shows grains variously coloured according to their crystalline orientation and varying in size according to the size of the mould in which the metal was cast. Cold-working was effected by crushing in a vice; feeble work crushed the grains, but under heavy pressure the edges of the grains became indistinguishable, and even under high magnifications it was impossible to detect anything but striæ in the direction of elongation. Subsequent annealing experiments showed that after a fortnight there were signs of spontaneous recrystallisation at the ordinary temperatures. The rate of growth, and ultimate grain-size obtained increased with the temperature of annealing. At the same time the increase in hardness brought about by crushing, diminished until it attained the value of that of the cast metal. The rate of recrystallisation is also increased by the degree of deformation. Under slight shock the crystals which have been caused to grow become crossed with striæ. Similar structures are sometimes observed in cast samples and are caused by shock in removing the metal from the mould.

F. C. A. H. L.

992. The Allotropy of Zinc. E. Cohen and W. D. Helderman. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 565-568, Dec. 27, 1918.)—Since the results of many workers point to the existence of a transition-point in zinc in the neighbourhood of 850° C. it might be expected that

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ordinary Zn forms a metastable system containing two or more allotropic modifications of the metal. This view is strengthened by the considerable variations found in the figures published for the density of Zn. Chemically-pure Zn was melted and cast in an asbestos-paper mould cooled in a mixture of solid CO₂ and alcohol. The resulting ingot had a density of 7.180. After heating to 100° C. in a solution of zinc sulphate (saturated at 15° C.) for 886 hours the density had fallen to 7.102. The authors consider that these experiments prove that "zinc" must be considered as a metastable system and that the variety found at high temperatures changes only very slowly into the modification stable at low temperatures. Since the difference in the specific volume of the two varieties is great, all objects made from zinc will disintegrate in the long run. This throws considerable doubt on the stability of deposits produced by the Schoop process—a subject upon which it is hoped to report shortly.

F. C. A. H. L.

993. *Hardness and Conductivity of Zinc-Cadmium Alloys.* A. Glasunow, and M. Matweew. (Int. Zeitschr. Metallg. 5. pp. 118–122, Dec., 1918.)—According to Hindrichs, the zinc-cadmium series shows a simple eutectic with no solubility in the solid, but in studying the hardness of this series, Saposchnikow and Sachorow obtained a complicated curve with two maxima. To clear up this discrepancy the authors have undertaken the study of the hardness and conductivity of these alloys prepared from Kahlbaum's pure metals and annealed at 225° C. for 84 hours. The conductivity of Cd is $\lambda_0 = 14.5$ and that of Zn, $\lambda = 18.1$, while the conductivity-concentration graph is a straight line. The hardness-concentration curve shows a maximum at the eutectic composition (82.6 % Zn). This was considered to be due to the surface tension and smaller crystallisation obtained in alloys of about the eutectic composition, and accordingly another series of alloys were hammered and annealed for 900 hours at 225° C. to attain the stable state. This series shows that the hardness of the stable alloys is a rectilinear function of the concentration. With a ball of 9.52 mm. diam. under a load of 200 kg., the Brinell hardness of Zn is 88.1, and that of Cd 22.0.

F. C. A. H. L.

994. *Researches on Bearing Metals. Antimony-Lead-Tin Alloys.* E. Heyn and O. Bauer. (Verein. z. Beförd. des Gewerbfleißes, Verh. [285 pp.] 1914. Supplement.)—The general requirements of bearing metals are discussed and a brief description of the Pb-Sb-Sn alloys used in practice (with or without the addition of Cu) is given with reference to their mechanical properties as determined by Charpy. In the Pb-Sb-Sn series a complete study has been made of the liquidus and solidification ranges of the alloys, extended by microscopic examination. The results have been summed up in a ternary model and diagrams showing the isothermals and the division of the liquidus surface into fields of like phases. Slowly-cooled alloys containing below 25 % Sb showed distinct tendencies towards segregation owing to the flotation of the specifically light, cubical Sb-rich crystals. Addition of Sn at first increased this tendency, after which further additions lowered the amount of segregation taking place. In actual practice steps must be taken to prevent this phenomenon by rapid cooling. The hardness of the alloys was found to attain a sharply defined maximum in the neighbourhood of 80 % Sn, 60 % Sb, and 10 % Pb. During the passage from pure Pb-Sb alloys to pure Sn-Sb alloys by gradual addition of tin the hardness first rose, then fell, then attained a second maximum, after which a rapid fall was

experienced. Study of the effect of annealing at 150° C. on the hardness of rapidly cooled alloys showed that while the hardness of Sn-rich (over 80 %) alloys was increased, that of the Sn-poor alloys was decreased by this treatment. Resistance to shock compression has been studied by subjecting cylindrical specimens to blows from a falling weight at temperatures of 100°, 20°, and -20° C. The number of blows required to cause cracking (or fracture in the case of brittle alloys) was counted, and at the same time the decrease in height of the specimen observed. Generally speaking the brittleness of the alloys was found to increase as the hardness increased, but the Sn-rich alloys containing less than 25 % Sb were found to combine considerable hardness with absence of brittleness under shock. Normal compression tests were also carried out and were found to follow closely the ball hardness tests, the Sn-rich alloys showing no anomaly in this respect. The relation between these properties and composition has been summed up in a number of the well-known triangular diagrams which should facilitate the choice of a bearing metal for any particular purpose. A study has also been made of the effect of Cu on these alloys. It has been found that even 2 to 8 % of this element greatly hinders segregation, and has the effect of raising the temperature at which solidification commences, this latter effect being most pronounced in the Pb-rich alloys. Rapidly cooled alloys containing copper were found to be harder and, in the majority of cases, less brittle than slowly cooled alloys of the same composition. It appears, therefore, to be of distinct advantage to effect rapid cooling of such alloys during solidification. The paper contains 85 tables and 288 diagrams in the text and 18 plates of photomicrographs.

F. C. A. H. L.

995. Spontaneous Recalescence of Quenched Steels at 100° C. H. Schottky. (*Ferrum*, 10. p. 274, 1918. *Rev. de Métallurgie*, 11. pp. 28-24, Jan., 1914. Extract.)—If a delicate thermometer be placed in a mass of hardened steel heated in a steam bath it is found that the temperature of the steel rises above that of the vapour by some tenths of a degree and falls to the normal value only very slowly. Experiments with a 0.89% carbon steel indicated that the recalescence increased with the temperature of quenching thus :—

An 89 % carbon steel quenched at	800° C.	1200° C.	1400° C.
Recalescence	0.80	0.35	0.40

Steels of varying carbon-contents showed the following results :—

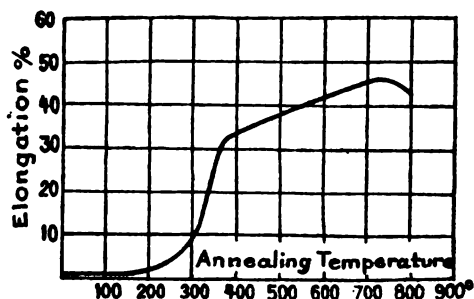
0.54 % carbon steel quenched at 1000° C. gave a recalescence of	0.15° C.
0.89 " " 1100 " "	0.35
1.22 " " 1000 " "	0.55
1.48 " " 1800 " "	0.88
1.60 " " 1850 " "	0.20

Other properties of the steel are found to be modified by this treatment. The change is probably due to the partial conversion of austenite into martensite.

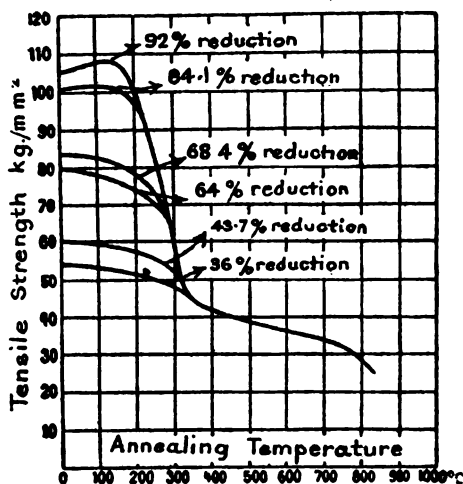
F. C. A. H. L.

996. Influence of Thermal Treatment on the Strength of Drawn Bronze. P. Goerens and J. Dumont. (*Ferrum*, 10. pp. 21-27, 1918. *Rev. de Métallurgie*, 11. pp. 80-88, Jan., 1914. Extract.)—A systematic study has been made of the effect of thermal treatment on the strength of bronze wires which have been mechanically hardened under known conditions, the reduction of area of the original section being taken as a measure of the degree of

cold-working. Using a bronze containing 94 % Cu and 6 % Sn, two series of tests have been made : one in which annealed wire 6.5 mm. in diam. formed the starting-point, and the other in which annealed wire 4.8 mm. in diam. formed the starting-point. The results are summed up diagrammatically in the accompanying Figs. They show that the increase of strength due to cold



work is almost directly proportional to the degree of mechanical hardening. Up to a certain temperature which decreases as the degree of cold work increases, annealing has little effect on the strength and ductility, but between this temperature and 400°C. there is a rapid fall in strength and increase in ductility. Above 750°C. both strength and ductility fall off owing to overheating of the metal. It would appear that the mechanical



properties of bronze annealed at temperatures above 815°C. are independent of the previous cold work carried out on the metal and that all mechanical hardening disappears after annealing at this temperature. The time effect in annealing is only observed below 815°C. ; at higher temperatures the whole effect is exerted in the first few minutes. The rate of cooling subsequent to annealing is without effect on the mechanical properties. F. C. A. H. L.

997. *Fragility produced in Iron and Steel by Deformation at Different Temperatures.* G. Charpy. (Comptes Rendus, 158. pp. 811-815, Feb. 2, VOL. XVII.—A.—1914.

1914.)—Recent researches have shown that the majority of steels show a max. fragility between 450° and 475° C. and that certain steels become very fragile after being worked at temperatures between 800° and 400° C. The author's work shows that all iron and steels do undergo a diminution of resilience after being worked at temperatures between 0° and 400° C. The decrease appears to attain a maximum at about 250° C.—a temperature corresponding to the max. tensile strength and minimum elongation observed by A. le Chatelier and the maximum of hardness observed by G. Robin. Purity appears to be the determining factor in the degree of reduction of the resilience, pure iron being only very slightly affected. Further, increasing the amount of deformation increases the lowering of the resilience. Tests made on 2 % and 6 % nickel steels show similar phenomena, and, further, indicate that nickel steels are more fragile than the corresponding plain steels.

F. C. A. H. L.

998. *Comparison of the Point at which the Solid State disappears with the Critical Point of a Liquid by means of the ψ -Curve.* J. D. van der Waals. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 39-40, Sept. 8, 1918.)

T. H. P.

999. *Rusting of Iron in Water.* W. A. Bradbury. (Chem. News, 106. pp. 807-808, Dec. 26, 1918.)—Many years ago Crace Calvert came to the conclusion that the rusting of iron in water was brought about by dissolved carbonic acid and oxygen, the former being the predisposing cause since no action occurred in its absence. These conclusions have since been widely supported. Experiments conducted by the author show that rusting takes place very rapidly in tap-water, while in well-boiled tap-water no rusting should occur. During rusting atmospheric oxygen is absorbed. The solution of iron by carbonic acid should result in the production of hydrogen, thus $\text{Fe} + 2\text{H}_2\text{CO}_3 = \text{FeH}_2(\text{CO}_3)_2 + \text{H}_2$, but in experiments with tap-water no gas could be collected over a week. Water saturated with CO_2 did evolve considerable quantities of gas. The experiments confirm the view that rusting is due to the combined action of oxygen and carbonic acid, and show that the oxygen is utilised in two ways: (a) in the oxidation of the nascent hydrogen liberated, and (b) in the oxidation of bicarbonate of iron to rust. Further tests showed that magnesium chloride solution does not act on iron in the absence of carbonic acid although it has been stated that such solutions do react with iron even in the cold according to the equation—



F. C. A. H. L.

1000. *The Porosity of Iron.* W. H. Perkins. (Chem. Soc., Journ. 105. pp. 102-106, Jan., 1914.)—The author has repeated and extended Friend's experiments [Abstract No. 408 (1912)] on the absorption of caustic alkalis by samples of iron. Experiments carried out in Pt-dishes with sodium, potassium, barium, lithium, and ammonium hydrates show that distinct traces of alkali are retained by iron and, in fact, other metals. Their extraction is a slow process of diffusion and is not hastened by shaking.

F. C. A. H. L.

1001. *Influence of Manganese on the Mechanical Properties of Grey Cast-iron.* F. Wüst and H. Meissner. (Ferrum, 11. pp. 97-112, Jan. 8, 1914.)—The object of the research has been to determine the upper limit of manganese permissible in grey cast-iron about which a considerable difference

of opinion has existed. Four series of irons (I, II, III, and IV) containing about 1.5 % Si, 2.7, 8.0, 8.8, and 8.9 % C respectively and in which the Mn varied from 0.1 to 2.5 %, were prepared and subjected to chemical analysis, bending, tensile, impact, and hardness tests and microscopic examination. Chemical analysis showed that the phosphorus and sulphur were low (below 0.08 and 0.01 % respectively) and that the graphite increased with increase of total carbon. Below 0.8 %, increase of Mn increases the tendency towards graphite formation, but between 0.8 and 2.5 % the Mn exerts no further influence on the form in which the carbon separates. The bending and tensile strengths of series I and II attain a maximum in the region of 1 % Mn. In series I, II and III the deflection during bending and the impact strength are first improved and then diminished by increasing Mn; hardness is steadily increased. In every case the worst mechanical properties are exhibited by the high-carbon alloys and the best properties are possessed by those alloys containing about 8 % carbon. Microscopic examination indicates that by increasing the amount of primary crystallisation, Mn decreases the solidification interval, and increases the stresses set up by the deposited graphite. This accounts for the weakening effect of high manganese additions. High carbon acts contrariwise by increasing the quantity of eutectic. Increasing Mn decreases the size of the graphite particles and the ferrite areas and renders the pearlitic structure much finer in character.

F. C. A. H. L.

1002. *Transformation-points and Structure of Nickel-Chrome Steels.* L. Guillet. (Comptes Rendus, 158, pp. 412-414, Feb. 9, 1914.)—The work described in Abstract No. 1550 (1913) has been continued, and a study made of the critical points, microstructures, resilience, and ball hardness of two series of low-carbon steels containing 2 % and 4 % nickel respectively and increasing amounts of Cr. In both series Cr decreases the resilience and increases the hardness, while the effect on the transformation points is summed up in the following table :—

2 % Nickel Steels.			4 % Nickel Steels.		
Cr %.	Ac °C.	Ar °C.	Cr %.	Ac °C.	Ar °C.
0.08	870	640	0	655-725	680-550
0.90	705	615	0.95	700	425
1.00	700	590	1.90	700	360
1.99	715	480	3.05	705	250
3.00	715	350	5.85	715	230
4.84	780	240	8.26	715	abt. 200
5.29	720	230	13.87	715	invisible
7.17	715	210			
10.25	720	invisible			

The lowering of the critical point is not directly proportional to the Cr-content and in the 4 % nickel series the lowering due to small proportions of Cr is greater than in the 2 % series. The steels may be classified into three groups : (1) Pearlitic steels in which the transformation-point on cooling is not more than 125 deg. C. lower than that on heating ; (2) martensitic steels commencing with those in which the critical point on cooling is at about 350° C. ; and (3) steels containing free carbide when the critical point on cooling is below 230° C. In the latter group the whole of the Cr is not held in solution, while the second group forms the class of air-hardening steels.

F. C. A. H. L.

1003. *Critical Ranges A2 and A8 of Pure Iron.* G. K. Burgess and J. J. Crowe. (Bureau of Standards, Bull. 10. pp. 815-868, 1914.)—An elaborate and detailed description of the apparatus used and methods employed in carrying out the research work dealt with preliminarily in Abstract No. 1540 (1918). The final results indicate that Ac2 and Ar2 occur at $768^{\circ} \pm 0.5$, while Ac8 occurs at $909^{\circ} \pm 1$ and Ar8 at $896^{\circ} \pm 2$. F. C. A. H. L.

1004. *A New Etching Agent for Steel.* W. Rosenhain. (Nature, 92. p. 529, Jan. 8, 1914.)—In conjunction with J. L. Haughton, the author has found that the acid solution of ferric chloride, frequently employed for etching copper alloys, containing about 0.1 % cupric chloride and 0.05 % stannic chloride is a most useful reagent in the microscopic analysis of steels. The ferrite in ordinary carbon steels is blackened, while pearlite and cementite remain white. In commercial steels the ferrite is not darkened uniformly, but appears to assume a banded structure. Copper appears to be deposited with the greatest rapidity on pure ferrite. Phosphorus exerts a considerable retarding action and the reagent is capable of indicating the distribution of phosphorus in a manner quite as striking and in much less time than is required by the process of heat-tinting. F. C. A. H. L.

1005. *Flame Reactions.* I. W. D. Bancroft and H. B. Weiser. (Journ. Phys. Chem. 18. pp. 218-268, March, 1914.)—While it is generally agreed that free metallic vapours exist in flames, there are differences of opinion respecting the way in which the metals are set free. No independent proof of the occurrence of free metals in flames has been given except in two separate cases studied by Salet and Smithells respectively. The authors have made a number of experiments in this direction, with the following results. At the temperature of the Bunsen flame many metallic salts are dissociated and the metal liberated, while in the oxy-hydrogen flame still more salts are similarly decomposed. The presence of free metallic vapours in a flame can often be shown by condensing the metals on a chilled porcelain tube. By precipitation from the Bunsen flame it has been found possible to prepare metallic mirrors of copper, cadmium, tin, silver, lead, bismuth, zinc, arsenic, and antimony, and to obtain mercury in the form of drops; from the oxy-hydrogen flame mirrors of molybdenum and tungsten have been prepared. Sulphur can be precipitated from the hydrogen-air flame containing SO_2 and, also, mixed with carbonaceous matter, from a Bunsen flame containing SO_2 . Red phosphorus can be precipitated from a hydrogen-air flame fed with phosphorus trichloride, and it seems probable that metallic sodium and potassium have been precipitated from oxy-hydrogen flames fed with sodium and potassium chlorides, but since these metals oxidise at once, the proof of their precipitation is not conclusive. The principle underlying the experimental results is that all exothermal compounds must decompose if at a sufficiently high temperature; the reducing action of the flame gases is not essential, although it may at times increase the decomposition. In the hydrogen-chlorine flame the dissociation of chlorides is retarded. When phosphorus burns relatively slowly, the flame is green just as when a phosphorus compound is added to a cooled Bunsen flame. T. H. P.

1006. *On Gelatinous Structures.* R. Zsigmondy. (Phys. Zeitschr. 14. pp. 1098-1105, Nov. 15, 1918. Paper read before the 85. Naturforscherversamml., Wien.)—Discusses the two main theories of gels: the honeycomb theory, according to which gels consist of minute elastic solid

chambers including liquid ; and the microcrystalline theory. Shows that both forms are extant. In the case of silica gels the porous character is proved by the reduction of vapour pressure of liquids absorbed by the gel, which again is due to the occurrence of numberless concave menisci. In the case of gelatine, the pores close on drying, so that other methods must be found for demonstrating the porous structure. The gelatinisation of soap solutions, barium malorate, congo red, and other substances is due to the formation of a microcrystalline felt.

E. E. F.

1007. *Distribution of a Colloidally Dissolved Substance over Two Layers.* W. Reinders. (Konink. Akad. Wetensch. Amsterdam, Proc. 18. pp. 879-885, Nov. 27, 1918.)—When three non-miscible liquids meet, two cases present themselves: (1) when none of the three contact surface tensions is greater than the sum of the other two, the three phases meet in one common side; (2) when, for instance, $\sigma_{1,2}$ is greater than $\sigma_{1,3} + \sigma_{2,3}$, 3 will expand between 1 and 2 and prevent contact between them. If one of the three phases is solid, the same two cases are distinguishable, except that in the latter, phase 3 arrives at the surface of contact of 1 and 2. Further, if phase 3 is suspended in the liquid 1 as a fine powder and this suspension shaken with liquid 2, one of three things may occur: (a) If $\sigma_{1,2}$ is greater than $\sigma_{1,3} + \sigma_{2,3}$, 3 will be completely enveloped by 1, in which the suspension thus remains unchanged; (b) if $\sigma_{1,2}$ is greater than $\sigma_{1,3} + \sigma_{2,3}$, the stable condition will be such that 3 is completely enveloped by 2, so that the suspension passes entirely from 1 to 2; (c) if $\sigma_{1,2}$ is greater than $\sigma_{2,3} + \sigma_{3,1}$, or if none of the three contact surface tensions is greater than the sum of the other two, the powder is deposited entirely on the surface of contact. In the case of a suspenoid in which solid floating particles are present, when these are fairly large and practically of uniform dimension, the surface tension in regard to the surrounding medium may be assumed to be but slightly dependent on this dimension, and hence the same for all the particles; the above three possibilities consequently apply here also. As the particles diminish in size, the resultant of the molecular attractions which appears as surface tension becomes dependent in high degree on the number of molecules together forming the particle. It will then be possible for particles below a certain size to pass into the second liquid and for larger ones either to arrive at the surface of contact or to remain in the first liquid. Finally, if the colloidal particles each consist of only a few molecules, the ideas of surface and of surface tension lose their significance; the solution is then an ordinary molecular one and the dissolved substance will distribute itself throughout the two liquids according to the law of distribution, factors other than surface tension then dominating the distribution. Complications may here arise owing to the union of the particles deposited at the surface of contact to larger coagulums, this happening readily with unstable solutions. With emulsoids or solutions in which the presence of floating liquid droplets must be assumed, these, if deposited at the surface of contact, may unite to form a separate liquid layer when $\sigma_{1,2}$ is greater than $\sigma_{2,3} + \sigma_{3,1}$. If, however, the separation at this surface has taken place because none of the three surface tensions was greater than the sum of the other two, the expansion of liquid 3 between 1 and 2 becomes impossible, and the isolated droplets of 3 will unite with greater difficulty.

In order to investigate these considerations experimentally, the author has examined the behaviour of several different colloidal solutions towards a second liquid. The results obtained show that case (b)—separation at the

surface of contact—is a very common one, instances of the other two cases being also found; case (b) is, indeed, so common that it will often be possible to determine the colloidal nature of a solution by exhibiting the separation at the surface of contact on shaking with a second liquid. The above cases refer to non-reversible or only partially reversible colloids. With typically reversible colloids such as gelatine, such separation at the limiting surface has also been observed, and this reaction has even been utilised for demonstrating the presence of these substances in a solution; in most cases, however, the total quantity deposited appears to be small. This adhesion to the surface of contact with a second liquid is, moreover, quite comparable with the surface adhesion of an added solid substance, as has been often observed with colloidal solutions.

T. H. P.

1008. Amalgams containing Silver and Tin. W. A. Knight and R. A. Joyner. (Chem. Soc., Journ. 108, pp. 2247–2262, Dec., 1918.)—The authors have made a study of the equilibria of amalgams containing silver and tin, and have also studied further the question of ageing [cf. Abstract No. 965 (1911)]. It has been found that the equilibrium diagrams, which have been carried up to 214° , can be grouped into two classes—those above about 70° containing a large proportion of solid solution and those below only negligible amounts.

A. F.

1009. Properties of Liquids as Functions of the Critical Constants. J. Kendall. (Medd. K. Vet. Nobelinstitut, 2, No. 29, pp. 1–28, 1918.)—The author derives the following expressions, which are found to agree with Young's experimental results [see Abstract No. 1785 (1910)] over the ordinary range of temperatures, (1) $Q = k(T_c - T)^n$, where Q is the latent heat of vaporisation, T and T_c are the temperature and critical temperature respectively, k is a constant characteristic of the particular liquid, and n a constant of the value 0.886, for all normal liquids. This formula and Trouton's rule together give the expression, $MQ = 20.7 T(1 - T/T_c)^n$, M being the molecular weight. (2) $\sqrt[3]{d} - \sqrt[3]{d_c} = k_1(T_c - T)^{\frac{1}{2}}$, in which d is the density of the liquid at T° , d_c the critical density, and k_1 a constant varying with the nature of the liquid. Further, $\sqrt[3]{d} - \sqrt[3]{D_c} = k_2(T_c - T)^{\frac{1}{2}}$, where D represents the density of the saturated vapour at T and k_2 is a constant for any particular substance.

The densities of liquids at absolute zero temperature, calculated from the above equations, agree well with Guldberg's extrapolated results. With all normal liquids, the ratio between the densities at absolute zero and at the critical temperature is approximately 8.75, the value given by Guldberg. Equation (2) thus takes the form $\sqrt[3]{d/d_c} - 1 = 0.558(1 - T/T_c)^{\frac{1}{2}}$, which is in fairly good agreement with the results obtained for normal liquids. The above equations, in conjunction with that of Mills for the heat of vaporisation, lead to the expression (8) $Q = 0.00081888 P(V - v) + k_1\mu(T_c - T)^{\frac{1}{2}} + k_2\mu(T_c - T)^{\frac{1}{2}}$, P being the vapour pressure, V and v the volumes of 1 gm. of the saturated vapour and the liquid respectively and μ a constant for any particular compound. It will be seen that equation (1) is an interpolation formula, the exponent, 0.886, being intermediate to those of the second and third terms of the right-hand side of equation (8). The latter takes the form, $Q = RT/M + k_1\mu(T_c - T)^{\frac{1}{2}} + \mu \sqrt[3]{d_c}$ for low temperatures, and in this the condition $dQ_0/dT = 0$ is satisfied if $k_1\mu M/8T_c^{\frac{1}{2}} = R$, which is the case with normal liquids.

T. H. P.

1010. Electrical Conductivity in Hydrocarbons and their Halogen-derivatives, in Esters, and in Bases as Solvents. I. and II. P. Walden. (Acad. Sci. St. VOL. XVII.—A.—1914.

Petersburg, Bull. No. 16. pp. 907-986, Nov. 15, and No. 17. pp. 987-996, Dec. 1, 1918.)—I. For investigating electrolytic conduction in inert solvents, tetra-*iso*-amylammonium iodide, $N(C_5H_{11})_4I$, has been found to be a specially suitable solute. Measurements have been made of the conductivity of this and of similar salts in—

Methylene chloride CH_2Cl_2 ,
Chloroform $CHCl_3$,
Carbon tetrachloride CCl_4 ,
Ethylene chloride $C_2H_4Cl_2$,
Acetylene tetrachloride $C_2H_2Cl_4$,
Propyl chloride C_3H_7Cl ,
Allyl chloride C_3H_5Cl

Ethyl bromide C_2H_5Br ,
Acetylene tetrabromide $C_2H_2Br_4$,
Methyl iodide CH_3I ,
Carbon disulphide CS_2 ,
Benzene C_6H_6 ,
Toluene $C_6H_5 \cdot CH_3$,
Benzyl chloride $C_6H_5 \cdot CH_2Cl$

The molecular conductivities were always small, only rarely rising to 15 units and often falling almost to zero. In many cases they showed the maxima and minima, which are characteristic of salts dissolved in solvents of relatively small ionising power, and which have been attributed to the development of "autolytic conductivity," (compare fused salts) in concentrated solutions.

II. Measurements were also made in the following solvents :—

Aniline $C_6H_5 \cdot NH_2$,
Quinoline C_8H_7N ,
Methylaniline $C_6H_5 \cdot NH(CH_3)$,
Sulphurylchloride SO_2Cl_2

Acetic Acid $CH_3CO \cdot OH$,
Ethyl formate $H \cdot CO \cdot OC_2H_5$,
Methylacetate $CH_3CO \cdot OCH_3$,
Methyl benzoate $C_6H_5 \cdot CO \cdot OCH_3$

The general results are summarised as follows :—All solvents, starting with benzene, toluene and chlorinated hydrocarbons (for which the dielectric constant $\epsilon = 2.2 - 2.8$) give conducting solutions. The conductivity depends (1) on the nature of the electrolyte, binary salts being the best, (2) on the concentration, since concentrated solutions in these feebly-ionising solvents give marked conductivity. On diluting, the molecular conductivity may (1) rise to a maximum and then fall rapidly without reaching a minimum, (2) rise to a maximum, fall to a minimum and then rise again, (3) rise continuously, without passing through a maximum or minimum. For a given salt, e.g. $N(C_5H_{11})_4I$ or $N(C_4H_9)_4I$, type (1) is found when $\epsilon = 2$, type (2) when $\epsilon = 4.95$ (chloroform) to $8-9-10$ (CH_2Cl_2 , C_2H_5Br , C_3H_7N , $C_2H_4Cl_2$) and type (3) when $\epsilon > 9$ or 10 . Salts with less ionising tendency, e.g. $N(C_4H_9)_3$, HCl , may, however, give maxima and minima in solvents of dielectric constant higher than 9.

It is further noted that (1) in solvents of equal viscosity, the molecular conductivity increases with the dielectric-constant ϵ of the solvent; (2) in solvents of equal dielectric constant, the conductivity increases as the viscosity decreases or as the fluidity f increases; (3) therefore the conductivity at a given dilution is a function of the dielectric constant and the fluidity of the solvent $\lambda_\infty = F(\epsilon, f)$.

Similar statements apply to the conductivity at the minimum-point (observed in solvents for which $\epsilon < 9$), the conductivity increasing with the dielectric constant and with the fluidity, until the growth of ϵ causes the minimum to vanish.

T. M. L.

1011. *Calculation of the Electrical Conductivity in very Dilute Aqueous Solutions.* S. Arrhenius. (Medd. K. Vet. Nobelinstitut, 2 No. 42, pp. 1-12, 1918.)—Assuming that the conductivity of water is due to carbonic acid, the
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methods usually adopted for correcting the conductivity of solutions of acids and salts for the influence of the solvent are justified theoretically where the salts are those of strong acids or the acids are stronger than acetic acid. With salts of weak acids the theoretical correction is less than that corresponding with the conductivity of the solvent, and depends, as a first approximation, on the ratio of the ionisation-coefficient, k , of the acid to the concentration, c , of the salt. The values of the relation between the actual correction and the conductivity of the solvent are given for a series of values of k/c . With very dilute solutions of sodium chloride and nitrate, the variation of the conductivity is in agreement with the requirements of the law of mass action, and this is probably the case with all electrolytes at sufficiently high dilutions.

T. H. P.

1012. *The Drop-weights of Aqueous Solutions of the Salts of Organic Acids.* J. L. R. Morgan and W. W. McKirahan. XIV. (Amer. Chem. Soc., Journ. 85. pp. 1759-1766, Nov., 1918.)

1013. *The Weight of a Falling Drop and the Laws of Tate.* XV. *Drop-weights of Certain Organic Liquids and the Surface Tensions and Capillary Constants calculated from them.* J. L. R. Morgan and P. M. Chazal. (Amer. Chem. Soc., Journ. 85. pp. 1821-1834, Dec., 1918.)—Twenty-five organic liquids were studied, of which nine (benzonitrile, *o*-, *m*- and *p*-toluonitriles, hexane, ethyl mercaptan, thiophenol, phenyl isothiocyanate, and ethyl acetoacetate) were found to be non-associated, and sixteen (ethyl isothiocyanate, allyl isothiocyanate, methyl malonate, ethyl malonate, ethyl dimethyl acetoacetate, ethyl diethyl acetoacetate, ethyl oxalate, acetonitrile, butyronitrile, valeronitrile, acetyl acetone, methyl cinnamate, ethyl cinnamate, phenyl hydrazine, monoacetin, amyl succinate) were found to be associated. The authors' results are, in some cases, in harmony with, in other cases divergent from, those of other workers. In the case of the toluonitriles the order of the surface tensions is ortho-, para- and meta-, the latter having the lowest surface tension, although the usual order is ortho-, meta-, para-. The authors consider that the conclusions of Schenck and Ellenberger that acetyl acetone and ethyl acetoacetate are tautomeric mixtures is not justified.

A. F.

1014. *The Weight of a Falling Drop and the Laws of Tate.* XVI. *Drop-weights of Certain Organic Liquids and the Surface Tensions and Capillary Constants calculated from them.* J. L. R. Morgan and B. J. Kramer. (Amer. Chem. Soc., Journ. 85. pp. 1834-1845, Dec., 1918.)—The surface tensions of twenty-four organic liquids have been determined at different temperatures, and the temperature equations calculated. On the whole, good agreement with the results of other investigators was found.

A. F.

1015. *The Weight of a Falling Drop and the Laws of Tate.* XVII. *Drop-weights and Surface Tensions of Molten Hydrated Salts and their Solutions.* J. L. R. Morgan and E. Schramm. (Amer. Chem. Soc., Journ. 85. pp. 1845-1856, Dec., 1918.)—Drop-weights have been determined and surface tensions calculated for thirty-two concentrations of calcium chloride in water solution, for 16 of zinc nitrate, for 14 of sodium chromate, and for 15 of sodium thiosulphate. It was found that supersaturated solutions behave, with respect to surface tension, exactly as ordinary ones do. The relationship between surface tension and concentration was in all cases found to be

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curvilinear and convex to the concentration axis. No change in curvature which would indicate the presence of any hydrate in solution was found in the curves. Valson's relationship, that salt solutions of equivalent concentration possess the same surface tension, was shown to be only approximately (5-6 %) true. Heydweiller's relationship connecting surface tension with the number of equivalents present and the ionisation was found in harmony with experiments only in some cases. A. F.

1016. *The Weight of a Falling Drop and the Laws of Tate. XVIII. Drop weights, Surface Tensions, and Capillary Constants of Aqueous Solutions of Ethyl Methyl, and Amyl Alcohols, and of Acetic and Formic Acid.* J. L. R. Morgan and M. Neidle. (Amer. Chem. Soc., Journ. 85. pp. 1856-1865, Dec., 1918).—In connection with the above measurements, the very large effect of even minute amounts of amyl alcohol on the surface tension of water is shown. The relationship of Duclaux that for aqueous solutions of homologous alcohols and acids the ratio of the concentrations of any two homologues in the solutions exhibiting the same surface tensions is constant, is confirmed. Evidence of mutual disassociation of liquids is not obtained. Associated liquids, when mixed, do not give for the mixture a surface tension equal to the mean of the two constituent surface tensions. A. F.

1017. *Solutions of Radio-active Products.* T. Godlewski. (Le Radium, 10. pp. 250-264, Aug., 1918. Paper read before the Acad. of Sciences, Cracovie, June, 1918.)—A solution of RaEm and its products in pure water was taken and electrolysed by a few milliamps. for about 90 secs. The anode was found to be activated with RaA and about 1/8 of its equilibrium amount of RaC. The kathode was found to be activated with RaB, and about 1/4 its equilibrium amount of RaC. The same results were obtained when the RaEm was first removed by bubbling, and only the active deposit particles were left; so that the charges on the atoms at the moment of their creation are not the determining factor. The magnitude of the e.m.f. used was shown to determine the speed of electrolysis but not the relative proportion of the products delivered to the anode or kathode. The author concludes that the radioatoms are not present in the solution as ions but as colloidal hydrosols, the RaA atoms constituting negative granules and the RaB positive, while those of RaC are either positive or negative. This hypothesis is verified by adding various electrolytes, such as HCl, $Al_2(SO_4)_3$, NH_4OH , $K_2C_4H_2O_7$, etc., the resulting distribution of the products at anode and kathode being always such as could be predicted from the known actions of these substances on colloids. For instance, the hydrogen ions from HCl diminish the number of negative suspensions, and increase the number of positive. By suitable concentration of various electrolytes it is shown that it is possible to vary the ratio of the anode and kathode activities by 1:40000. E. M.

1018. *The Occurrence of an Upper Critical Point of Mixing and the Coexistence of Two Mixed Crystal Phases.* A. Smits and C. A. L. de Bruyn. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 557-564, Dec. 27, 1918).—When a fused mixture of KCl and NaCl is suddenly cooled the resulting solid mass has different properties (heat of solution, etc.) from that obtained on slow cooling. The authors have investigated this more fully, and they find that the mixed crystals of KCl-NaCl break up on slow cooling into two sets of mixed crystals, the composition of which depends on the temperature. In other words, there is a partial miscibility for KCl-NaCl in the solid state, and this

curve exhibits a maximum point, beyond which there is complete miscibility, at a temperature of 407° , the composition at the solution at this temperature being 66.6 moles per cent. of NaCl.

A. F.

1019. Equation of State, Diagram of State, and Association Hypothesis. L. Schames. (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1017-1026, Oct. 20, 1918. Paper read before the Deutsch. Naturforscherversamml., Sept., 1918. Phys. Zeitschr. 14. pp. 1172-1175, Nov. 15, 1918.)—The author discusses the diagram of state deduced on the basis of the association hypothesis [Abstract No. 1858 (1912)]. This reduced equation of state takes the form—

$$\left(\omega \frac{c}{c_k} - \frac{1}{8}\right) \left(\pi + \frac{8}{\omega^2 \theta} \frac{c-1}{c_k-1}\right) = \frac{8}{3} \theta,$$

and does not exhibit the disagreement with experiments such as is shown by van der Waals' equation. From this equation, also, one is led to the assumption of an ideal liquid for which van der Waals' equation of vapour pressure would be accurate. This latter equation gives a condition of existence of the true liquid state and leads to a modification of the diagram of state, which in turn points to the existence of a second critical point for liquid-solid in the case of normal substances, including water under very high pressures.

A. F.

1020. Critical State and the Theory of Continuity. I. Traube. (Deutsch. Phys. Gesell., Verh. 15. 22. pp. 1219-1224, Nov. 20, 1918.)—Unsuitable for abstracting.

1021. Viscosity of Calcium Chloride Solutions. F. Simeon. (Phil. Mag. 27. pp. 95-100, Jan., 1914.)—The results are given in the form of tables, and compared with those of Tucker by means of curves.

L. H. W.

1022. Thermal Calculation of Electromotive Forces. J. N. Brönsted. (Zeitschr. Elektrochem. 19. pp. 754-757, Oct. 1, 1918.)—The calculations concern the silver chloride/calomel and the lead chloride/calomel cells. The heat of reaction $\text{Hg} + \text{AgCl} \rightarrow \text{Ag} + \text{HgCl}$ is 1420 cals. according to the author's recent, and 1400 to his previous measurements; the heat of reaction $\frac{1}{2}\text{Pb} + \text{HgCl} \rightarrow \text{Hg} + \frac{1}{2}\text{PbCl}_2$ is similarly 10,780 cals. (11,000 previous value). Pollitzer's values for the two reactions, 550 and 11,740 cals., are incorrect, and Pollitzer is criticised by the author, who calculates by Nernst's theorem e.m.f.'s of 0.026 and 0.514 (against 0.028 and 0.521 observed) volt for the two cells at the temperature $T = 234^{\circ}$. In these calculations the recent valuations of Nernst and Lindenmann for the specific heats are adopted.

H. B.

1023. Potential-drops at the Boundary between Liquid and Gas. L. v. Putnoky. (Zeitschr. Elektrochem. 19. pp. 920-928, Dec. 1, 1918.)—Quincke observed in 1860 that gas-bubbles migrate in water towards the positive pole, like suspended solid particles. The author shows theoretically that the potential liquid/gas should be deducible from the rates at which gas-bubbles rise in the space between the electrodes of an electric field when this field is excited or not. The experimental verification of the formula with the aid of electrodes of palladium and air-bubbles in water (pure or saturated with camphor) were unsatisfactory, however, because the bubbles began to oscillate when the field was turned on; yet the experiments show the existence of the effect. It is described how bubbles can be liberated from a capillary at regular intervals.

H. B.

1024. *Application of the Theory of Allotropy to Electromotive Equilibria.* A. Smits. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 699-710, Jan. 29, 1914.)—The author applies the theory of allotropy to the electromotive equilibrium between a metal and an electrolyte, in which it appeared that a metal exhibiting the phenomenon of allotropy, and consequently composed of molecules differing in their degree of association, will emit, when immersed in an electrolyte, ions of different kinds [see Abstract No. 1279 (1912)]. It is demonstrated that the "unary" electromotive equilibrium belongs to the Δ, x -figure of a pseudo-system, which may be realised for the case when the molecules and ions of the metal are not interconvertible, e.g. in presence of a negative catalyst.

Application of this view to the phenomenon of electrolysis leads to the following results. Firstly, it is made clear that, and why, in many cases of electrolytic deposition of metal, the metastable and not the stable phase will be obtained. Secondly, the theory shows that, when the internal transformations under negative catalytic influences fail to appear or are impeded, the metal that is made to dissolve electrolytically will get less base superficially, whereas the freshly deposited metal will be baser than that passing into solution. Next, it is rendered probable that the periodic oscillations in the p.d., which point to a periodic ennobling of the metal surface, may be accounted for from the same point of view. It is further demonstrated why the contact of a metal with a solution of one of its salts must exert an accelerating influence on the establishment of the internal equilibrium of the metal. Finally, attention is drawn to the possibility that on reduction of metallic compounds at low temperatures, masses of metal are obtained which are far removed from the condition of internal equilibrium and can exhibit abnormally great chemical activity; this will be the case when they differ from the ordinary metallic states by a greater content of the more simple molecules. The pyrophoric state is perhaps explainable in this way.

T. H. P.

1025. *A New Hydrogen Electrode and its Applicability.* E. Wilke. (Zeitschr. Elektrochem. 19. p. 857; Discussion, pp. 857-858, Nov. 1, 1918.)—The ordinary hydrogen electrode being unsuitable for working in viscous fluids like blood serum, in which the gas diffusion is very slow, the author forces hydrogen under pressure into a thin-walled palladium capillary through which it diffuses; Madelung had already used such capillaries for other purposes. This electrode keeps constant against a calomel electrode for weeks and can then be brought back to its former activity (which seems to be impaired when hydrocarbons and fats penetrate into it) by being heated in oxygen. The potential depends upon the pressure quotient inside and outside; varying the inner pressure by 100 atmos., the potential changed by 60 millivolts. The presence of other gases, hydrogen, CO_2 , even oxygen, outside the capillary seems to have little influence. F. Auerbach and F. Krüger pointed out during the discussion that, since the pressure of the hydrogen on the outer surface was not well defined, the e.m.f. of the electrode could not be definite and constant.

H. B.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1914.

GENERAL PHYSICS.

1026. *Elastic Hysteresis in Steel*. F. E. Rowett. (Roy. Soc., Proc. Ser. A. 89. pp. 528-548, March 2, 1914.)—Describes experiments made in amplification of work by Hopkinson and Trevor-Williams [see Abstract No. 826 (1918)] to determine whether the dissipation of energy per cycle of stress increased with the frequency. Thin-walled tubes were employed in order to secure higher accuracy in the measurement of the static hysteresis. In the high-speed cycles one end of the tube was fixed, and a flywheel was mounted on the other end. By this means the tube was set in torsional oscillation, and the amplitude of vibration being recorded photographically, the rate of decay gave the hysteresis loss. The effect of air friction was investigated by attaching to the flywheel, at some distance from it, a light disc of similar dimensions and determining the new energy-loss. The air-friction loss was thus found to be of the order of 7 % of the hysteresis loss in the case of annealed steel tubes, but far more important in the case of hard steel, in which the hysteresis loss was reduced to approximately one-eighth. In the annealed tube the loss per cm.^2 per cycle, with a stress-range in shear of 1160×10^6 dynes per cm.^2 , was found to be about 11,000 ergs, and to vary approximately as the cube of the stress-range. In the static experiments the torque was transmitted to the experimental tube by means of a long auxiliary tube, the strain being measured by means of micrometer screw levels. In this way the tube was taken repeatedly round a cycle of some particular stress-range, and observations of stress and strain were taken at different points on the cycle. The value obtained for the ratio of mean to maximum width of the hysteresis loop was 0.506, and the author considers this ratio to be substantially independent of the stress-range. The width of the loop at zero stress was determined for a number of stress-ranges and the corresponding areas were deduced, using the constant obtained above. The areas thus calculated agreed well with the dissipation energies determined by the dynamic experiments. It was also found that by using this constant the hysteresis found by Hopkinson and Trevor-Williams in their static cycles was

brought into almost exact agreement with that found by them at high speeds. A full description of the apparatus and methods used is given. J. W. T. W.

1027. *Torsional Oscillations in Nickel-wires in Alternating Magnetic Fields.* W. Brown and J. Smith. (Roy. Dublin Soc., Proc. 14. 14. pp. 215-223, Feb., 1914.)—Experiments were made with Ni-wires subjected to the influence of alternating magnetic fields of different frequencies, and it was found that with *hard* wire the damping curves with alternating fields lie below those obtained with a direct longitudinal field. When an alternating magnetic field had been on for 8 minutes and was then taken off, and afterwards a direct current through the magnetising solenoid was put on of the same value as had been previously employed, at first the deflection on scale caused by twist of wire was much less, being 1 mm. instead of 41 mm. This change, which the authors call temporary magnetic fatigue, is easily recovered from. The tables and curves given show clearly the effect of an alternating magnetic field in decreasing the damping of torsional oscillations in a soft Ni-wire. In a *hard* wire the damping due to an alternating magnetic field is *greater* than that due to an equivalent direct magnetic field, whilst in the case of the *soft* wire the damping due to the alternating field is *less* than that due to the equivalent direct field. Moreover, the damping due to a direct field is much greater in a soft Ni-wire than in a hard one; whilst the damping due to an alternating field is greater in a hard Ni-wire than in a soft one. The same effect is obtained when smaller or larger loads are on the wire. [For an account of experiments in fields produced by continuous currents see Abstract No. 788 (1911).] J. J. S.

1028. *Plastic Properties of Rock-salt.* K. Kleinhanns. (Phys. Zeitschr. 15. pp. 862-868, April 1, 1914.)—Rock-salt has been found to become plastic at a temperature of 150-200° C., whereas its melting-point is 820° C. The author's qualitative experiments on the bending of rods of rock-salt immersed in various liquids (water, oil, salt solutions, acids, alkalies, and organic substances) seem to indicate that when the rock-salt is immersed in a medium in which it is soluble, bending takes place far more readily and at a lower temperature than when it is immersed in a non-solvent. The author promises quantitative experiments on the same subject. J. W. T. W.

1029. *The Compressibility of Ice.* T. W. Richards and C. L. Speyers. (Amer. Chem. Soc., Journ. 86. pp. 491-494, March, 1914.)—The authors find that the compressibility of ice between 100 and 500 megabars is 0.0000120 at -7.08° C., or about one-quarter of the compressibility of water at neighbouring temperatures. It is found not to decrease remarkably as the pressure increases. There is a large temperature coefficient. A. F.

1030. *Units and Symbols, A.E.F. Committee.* (Elektrotechn. Zeitschr. 85. pp. 280-281, March 5, 1914.)—Weight = a force, mg. Mass-density or specific mass = mass/volume. Weight-density or specific gravity = weight/volume. Density = ratio of mass-density or sp. gr. of a body to that of a standard substance (usually water at 4° C.). Mass-volume = volume/mass; weight-volume = volume/weight. Symbols:—Energy, W; period, T; frequency of cycle, ω ; frequency in alternating current, f ; specific resistance, ρ ; conductivity, G; electrostatic induction, D; dielectric constant, ϵ ; counter-inductivity, M; magnetic flux, Φ . Unit of heat energy the international kilojoule or kilowatt-second ($= 0.238865 \text{ kg.-cal.}^{100} = \frac{1}{4190} \text{ kg.-cal.}^{100}$). A. D.

1031. *Structure of the Atom*. E. Rutherford. (Phil. Mag. 27. pp. 488-498, March, 1914.)—This paper and an accompanying one by C. G. Darwin [see next Abstract] are devoted to the further experimental confirmation by the author and others of his theory of atomic structure [Abstract No. 1847 (1911)]. Geiger and Marsden's experiments [Abstract No. 1296 (1913)] were in close accord with the theory. C. T. R. Wilson's photographs of trails of α -particles [Abstract No. 1885 (1912)] afford convincing evidence of great sudden deflections through encounter with a single atom. The independence assumed for these deflections of the external electrons of the atom can hold only for charged particles of very large kinetic energy, and therefore not for ordinary cathode particles or the recoil atoms from active matter. Large scattering of β -particles passing near a nucleus are to be expected, and Crowther's experiments [Abstract No. 1607 (1910)] can be generally explained on the nuclear theory. But here the interaction is not repulsive, but attractive, and Darwin has shown [Abstract No. 888 (1918)] that under certain conditions the β -particle will be drawn in a spiral orbit into the nucleus, which may explain the disappearance of swift β -particles in passage through matter. Some experiments by Marsden, soon to be published, confirm Darwin's conclusions [loc. cit.] as to the long range of the recoil H-particles. The latter's calculation of nuclear dimensions affords strong support to the author's theory, and further raises the question whether the H-nucleus may not be so small as to allow of its mass being accounted for as is that of the negative electron. It may, indeed, be the positive electron, with a mass entirely electromagnetic. If so, the helium atom should contain 4 positive and 2 negative electrons. Experiments by the author and Robinson show that if H or other atoms, as well as those of He, are expelled in radio-active transformations, their number must certainly be less than 1 in 10,000 of the number of the atoms. The He nucleus must therefore have a very stable configuration, capable of surviving the intense disturbance resulting from its expulsion with high velocity from the radio-active atom, so that it forms one of the units of which possibly the great majority of atoms are composed. This agrees with the radio-active evidence that atomic weight of successive products decreases by four units on expulsion of an α -particle. Atomic mass depends on the whole system of electrons, and the nucleus being so minute, the + and - electrons must be very closely packed, so that, as Lorentz has pointed out, the electromagnetic mass will depend on the interaction of their fields as well as on their number. This may account for the He-atom having not quite four times the mass of the H-atom.

On the nuclear theory the α -particle has its origin in the nucleus, and acquires much, if not all, its energy in the expulsion. The same is to be expected for the β -particles, as is Bohr's conclusion. The energy lost in β - and γ -rays during formation of RaC being above a quarter of the energy of the expelled α -particle, could hardly be derived from the electronic distribution. The conclusion of the author's theory that the number of electrons in an atom is about half the atomic weight in terms of H, is also Barkla's independent conclusion from the scattering of X-rays. But if H have one electron and He have two, the number cannot be exactly half the atomic weight in all cases, which led to van den Broek's suggestion [Abstract No. 812 (1914)], which accords with Bohr's view. As the latter has observed, gravitation and radio-activity, being unaffected by chemical or physical agencies, must be ascribed mainly or entirely to the nucleus, and the ordinary physical or chemical properties to the external electrons. On this view the nuclear charge is a fundamental constant of the atom, while the atomic mass may be a

complicated function of the arrangement of units forming the nucleus. If the latter consist of H-nuclei with one charge and He-nuclei with two charges, many atoms are *a priori* possible with varying atomic masses and identical nuclear charges, as is suggested by the radio-active evidence.

G. W. DE T.

1032. *Collision of α -Particles with Light Atoms.* C. G. Darwin. (Phil. Mag. 27, pp. 499-506, March, 1914.)—The large angle deflections of α -particles led to Rutherford's hypothesis of atomic constitution, but his calculations involve the assumption that the atom is so heavy as to remain sensibly unaffected by the collision. The author modifies and extends Rutherford's work by removing this restriction. Calling M the mass of the particle, and m that of the atomic nucleus, there are three cases to consider, according as m is greater than, equal to, or less than M . When γ is the number of α -particles with deflection ϕ observed within a solid angle ω , an expansion is obtained for γ as a function of ϕ and M/m , and in powers of the latter. *First case: $m > M$.* This applies to all substances except helium and hydrogen. The first term of the expression gives Rutherford's expression. If M/m were as high as $1/8$, as it would be for carbon, the velocity of the carbon nucleus might rise as high as $V/2$, V being the initial velocity of the α -particle. Such a particle might possibly be perceptible, but it is doubtful whether the shock would free the nucleus of all its electrons; thus the experimental conditions to reveal it are rather hard to imagine. *Second case: $m = M$.* The α -particle now travels through He. In this case no particle can be deflected through more than a right angle, and to the number of α -particles must be added the He-atoms which have been set in motion so as to strike the screen, for the recoiling particles should be quite indistinguishable from the true α -particles. *Third case: $m < M$.* The α -particles travel through H, and $m = M/4$. The number of particles, as observed by the scintillations, will be composed of particles of three types, slow α -particles, fast α -particles, and the recoiling H-particles which will move more rapidly than either of the other groups. In passing through matter these will be retarded like α -particles, and Bohr's formula [Abstract No. 651 (1918)] shows that the range of an H-particle will be slightly less than an α -particle of the same initial velocity. Bohr's formula ceases to hold for small velocities, but Geiger's empirical formula $V^3 = V_0^3 (1 - x/R)$ leads to the conclusion that corresponding to a range of 81 cm. of an α -particle, the range of an H-particle will be 28 cm. If an α -particle from RaC at its highest velocity strikes a nucleus straight on the initial velocity of the H-particle will be $8/5 \times 2 \times 10^9$ cm. per sec., and its range comes out at 117 cm. It would probably be greater than this, as at high speeds the range should be more nearly proportional to V^4 than to V^3 . The H-particles should therefore be easily observable if they can be made to occur in sufficient numbers. Their scattering should be greater than for α -particles, for the most probable angle of scattering depends on E/M [Abstract No. 1706 (1912)], and so is twice as great for H- as for α -particles. Geiger and Marsden's experiments are strongly confirmative of the nuclear hypothesis, and no force proportional to a power of the distance other than the inverse square can give the observed relation between γ and V . An upper limit to the size of atomic nuclei is calculated from the distance of closest approach between the α -particle and nucleus. For gold the number of deflections was observed up to $\phi = 150^\circ$, and found correct. Taking charge of nucleus 100 times electronic charge, and $V = 2 \times 10^9$ cm. per sec. gives 8.5×10^{-13} cm. as closest approach. In a straight-on collision with a

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H-nucleus it would be 1.7×10^{-18} cm., which would lead to the result that the radii of the nuclei of H and He are certainly less than 10^{-18} cm.

G. W. DE T.

1033. Remarkable Upper Air Records at Batavia. W. van Bemmelen. (*Nature*, 98. pp. 5-6, March 5, 1914.)—Two balloons liberated at Batavia in Nov. and Dec., 1918, reached the stratosphere and encountered remarkably low temperatures at its base. In one case the minimum registered was -91.9° C. and in the other -90.9° . The former is believed to be the lowest natural air temperature ever recorded. Another remarkable feature of this ascent was that above the level of this minimum (17 km.) the temperature rose to -57.1° C. or about its usual value in the stratosphere over Europe. On only two previous occasions has the height of 20 km. been exceeded at Batavia and on one of these a similar large rise of temperature was found in the stratosphere.

J. S. Di.

1034. The Atmospheric Obscurity of 1912-18. J. Maurer and C. Dorno. (*Meteorolog. Zeitschr.* 81. pp. 49-62, Feb., 1914.)—At the beginning of 1918 the President of the Radiation Commission of the International Meteorological Committee, J. Maurer, issued a circular letter to meteorological institutes asking that observational material on the remarkable atmospheric obscurity of 1912 should be sent to him. The paper is a report on the results obtained on working up the material received in response to the letter.

The general cause of the obscurity is attributed to the volcanic eruption of Katmai in Alaska, on June 6, 1912; for successive phases of obscurity can be traced from place to place in relation to the time which had elapsed since the eruption. The first phase began on June 6 in the form of high, clear clouds which travelled from WNW. to ESE. This phase reached Zürich on June 23, Egypt on June 28, and it was not sufficiently intense to affect the records of Campbell-Stokes sunshine recorders. The max. intensity of this phase at any place usually occurred from 1 to 8 weeks after the commencement. The second phase, which was similar in character to the first, was observed on Mount Wilson on June 21. It reached Algiers on July 11 and Egypt on Aug. 8. The third phase was noted in Washington to commence from July 19 to 26, and it arrived in Egypt at the end of Aug., but this phase was lacking altogether at some stations, while at others the maximum of disturbance occurred during its course. The fourth phase spread from America to Egypt during the month of Sept. The end of the disturbance was noted in Oct. at most places. The phenomena appear to be confined to that part of the Northern Hemisphere which lies between the polar circle and the tropic of Cancer, but it is not ascertained whether they extended completely round the globe, within those limits.

R. C.

1035. Influence of the Wind on Height of Barometer at High-level Stations. G. v. Elsner. (*Abhandl. d. Königl. Preuss. Meteorolog. Inst.* 4. No. 8. *Meteorolog. Zeitschr.* 81. pp. 98-95, Jan., 1914.)—Simultaneous observations of pressure at pairs of stations—one high-level, the other low-level—are compared by reducing the reading of the barometer at the high station to that at the level of the low by the usual barometric formula, and noting the difference between the reduced value and the observed reading at the low-level station. The differences are grouped according to the wind-force observed at the high-level station, and it is found that the mean difference

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(low-level reading—reduced high-level reading) is nearly zero with light winds and becomes positive as the force increases. For force 5 on the Beaufort scale the mean difference for three pairs of stations is 0·8 mm.; for force 8 it is 1·8 mm.; for force 11 it is 3·5 mm.

The probable causes of the differences are discussed, and it appears that the suction effects of the wind over chimneys and on windows open to the leeside of the upper station is one of the principal of them, while the uprush of air along the mountain-slopes may contribute towards the observed results.

R. C.

1036. *Meteorological Observations of Captain Scott's Last Expedition.* G. C. Simpson. (Review by J. v. Hann. Meteorolog. Zeitschr. 81. pp. 62-67, Feb., 1914.)—A complete set of self-recording instruments for temperature, pressure, wind velocity and direction, sunshine, atmospheric electricity, and terrestrial magnetism was erected and maintained in operation at Cape Evans. Regular eye observations of the usual meteorological instruments were made, while records of temperature and air-currents up to 8 km. were obtained by means of registering balloons and pilot balloons. In addition, absolute observations of the magnetic elements were conducted every week, also hourly observations of aurora during the whole time it was visible. Studies on meteorological optics, investigations on ice in the air and water, and gravity determinations were other subjects to which Simpson, the meteorologist of the expedition, turned his attention.

At Cape Evans the lowest temperature recorded was $-45\cdot6^{\circ}\text{C}.$, but in a sledge journey on the ice barrier the much lower value of $-60^{\circ}\text{C}.$ was observed in July, 1911. Cape Evans was subject to a series of remarkable blizzards, which were not experienced at Amundsen's quarters (Framheim) at the same time. At the latter station 42 % of the winds were of less than 4 miles/hour, but at Cape Evans the percentage of such winds was only 80%. At Framheim the percentage frequency of higher winds rapidly fell off to zero, but at Cape Evans, after a slight falling off, there occurred a distinct increase of frequency to 7·8 % for winds of 25-29 miles/hour. Above that velocity the frequency diminished slowly, but winds above 60 miles/hour were recorded, while at Framheim there was nothing greater than 45 miles/hour. The blizzards were characterised by extreme gustiness, and also by the suddenness with which they commenced. The mean temperature at Cape Evans was $-18\cdot0^{\circ}\text{C}.$, compared with $-24\cdot4^{\circ}\text{C}.$ at Framheim, situated 1° further south. The considerably lower mean temperature there is probably connected with the comparative absence of wind. The potential gradient is remarkable in that it shows a max. value in the summer, whereas in the Northern Hemisphere the maximum occurs in winter. The max. and minimum values in the Antarctic occur simultaneously with the corresponding phases in the Northern Hemisphere.

R. C.

1037. *Observations on the Increase of Insolation with Elevation.* H. H. Kimball. (Mount Weather Observatory, Bull. 6. pp. 107-110, 1914.)—A record of simultaneous observations on the radiation received at two neighbouring stations at different heights above sea-level. The first series was made at Mount Weather (1720 ft. above M.S.L.) and Trapp (720 ft.) and showed that on the four days of observation from 4 to 6 % of the radiation reaching the upper station was absorbed before reaching Trapp, 1000 ft. below. Other similar observations were made at Santa Fe, on a plateau 7000 ft. high, and at neighbouring mountain-peaks 8000 and 12,200 ft. high respectively. Great accuracy was not obtained in the readings, but it

appeared that from 0.5 to 2 % of the insolation which reached the peak at 8000 ft. was absorbed before it reached the plateau, and from 2.5 to 4 % was absorbed in the case of the 12,200-ft. peak.

J. S. DI.

1038. *Preliminary Results of Measurements of the Rigidity of the Earth.* A. A. Michelson. (Astrophys. Journ. 89. pp. 105-188, March, 1914.)—First attempts to measure the earth's rigidity, i.e. the resistance which it offers to change of shape, were made by G. H. and H. Darwin in 1880, employing the horizontal pendulum method for measuring change in gravitational vertical due to attraction of sun and moon, and comparing with values calculated on basis of absolute rigidity. The results obtained were very irregular and contradictory, but though the Darwins expressed the belief that such experiments were unlikely to be successful, yet in the hands of Rebeur-Paschwitz positive results were found confirming Kelvin's deductions that the earth must be considered a very rigid body. The method has since been successfully employed by Ehlert, Kortazzi, Schweydar, Hecker, and Orloff, with essentially the same result—namely : that the coefficient of rigidity is found to be of the order 6×10^{11} c.g.s. (about that of steel). In addition to the elastic yielding of any body ordinarily looked upon as solid there is a plastic yielding, characterised by a constant termed by Maxwell the "modulus of relaxation," and evidenced by a lag of the distortion of the earth relative to the forces producing it. Now such experiments as the above should be capable of determining the earth's plasticity as well as rigidity, but a discussion of the various results shows that the retardation of the phase of the observed motion relative to the phase of the disturbing forces which should always be negative, is in the majority of cases positive, so that the data further than showing that the lag is small (and therefore the viscosity high) are practically valueless. It was in the hope of obtaining results of a higher order of accuracy, as well as such directness and simplicity of apparatus as practically to eliminate all the difficulties and uncertainties which seem to be unavoidable in the use of the horizontal pendulum, that the present experiments were undertaken. The prime object of the investigation is the determination of the direction-changes of the gravitational vertical due to the attraction of the sun and moon, and as modified by the resulting distortion of the body of the earth. These may be furnished with any desired accuracy by changes in the position of the level of a liquid surface which is necessarily normal to the resultant of all the forces acting, followed by elimination of all but gravitational forces. A very sensitive method of measuring changes in level was devised using the interferometer, and a thorough preliminary investigation made to ensure its accuracy. A continuous series of observations were then conducted along an E.-W. and a N.-S. line, the apparatus comprising 6-in. pipes 500 ft. long, half-filled with water whose level could be read off through the glass sides of the end vessels. The pipes were laid in trenches 6 ft. deep, terminating in two pits, 8 ft. square and 10 ft. deep, walled with concrete. Copious experimental details are given in the paper, as well as numerous tables of observations and their graphs. There was found to be a disagreement between the E.-W. and N.-S. directions, and while Hecker, who found a similar difference, interprets this as indicating an actual difference in the earth's rigidity in these directions, Schweydar agrees with Love in attributing it to the effect of ocean tides and shows on the assumption of an ocean covering the earth uniformly to a depth of 5000 metres that the tides have the effect of increasing the elastic earth tides, so that the ratio of the observed amplitudes to the theoretical is diminished by something like

40 %. The values of the earth's rigidity n and viscosity ϵ are given as: $n = 8.6 \times 10^{11}$ c.g.s.; $\epsilon = 10.9 \times 10^{16}$ c.g.s. This calculation is based on the assumption of uniform rigidity throughout the body of the earth, a condition which is certainly not fulfilled, but it is clear that the earth's rigidity is greater than that of steel, while the viscosity is probably of the same order of magnitude as that of steel. The author believes this method to be capable of giving results of a high order of accuracy by recording a much longer series of observations, such being now in progress, and it is expected that the results will furnish a record of the earth tides correct to within a tenth of 1 %. The conclusions from these and similar experiments all agree substantially in refuting the old notion that the internal temperature, sufficiently high to melt most of the materials constituting the earth's crust, necessarily involves a fluid or semi-fluid earth supporting a relatively thin solid crust. Laboratory experiments are being undertaken on the interesting deduction that pressure increases the rigidity and viscosity of the materials forming the body of the earth.

H. H. Ho.

1039. *Equatorial Current of Jupiter.* T. E. R. Phillips. (Roy. Astronom. Soc., M.N. 74. pp. 116-118, Dec., 1918.)—In the late summer of 1912 the north equatorial belt of Jupiter began to exhibit a revival of activity. In the spring of 1918, it was found that the north equatorial belt was broad and strong, with a series of very dark protuberances along its south edge and light bays between them. As these developed a number of curved wisps extended from them like festoons, completely enclosing the light areas. Finally the south portion of the zone became shaded, giving the appearance of a number of egg-shaped areas ranged regularly round the north part of the equatorial zone. Altogether 850 transits of the dark and light areas were observed, showing that the main spots were 28 in number, and that they were all drifting at an unusually rapid rate. The mean rotation period thus determined is 9h. 50m. 12.2s. The motion was not uniform.

C. P. B.

1040. *Spectra of Wolf-Rayet Stars.* J. W. Nicholson. (Roy. Astronom. Soc., M.N. 74. pp. 118-182, Dec., 1918.)—Premising that the tendency of modern opinion is to regard the Wolf-Rayet stars as probably the earliest type known, being the first products of some form of evolution which has taken place in primitive nebulae, the electronic theory is applied to deduce the relationships existing between the various lines constituting their spectra. The chief clue to the elucidation of the spectra analytically appears to be the remarkable constancy of ratio of wave-lengths of several pairs of lines, thus suggesting the presence of series of Balmer's type. It is then shown that it is possible to represent the typical spectrum of a Wolf-Rayet star in a manner relating it to the nebular spectrum. Excluding the lines of helium and hydrogen, practically every other line comes into the scope of these series, determined from the analysis of a system of one atom with four electrons in its ring.

C. P. B.

1041. *Light-curve of Andromeda Nebula (NGC. 224).* J. H. Reynolds. (Roy. Astronom. Soc., M.N. 74. pp. 182-186, Dec., 1918.)—Measurements were made with a photomicrometer on negatives of the Andromeda nebula obtained with a 28-in. reflector (10 ft. focal length), on Oct. 7, 8, and 17, 1912. The results are tabulated and also given in the form of a curve showing the variation in intensity from the centre of the nebula outwards. The curve is remarkably similar to the curve having for its equation $(x+1)^y = \text{const.}$

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C. P. B.

LIGHT.

1042. *Infra-red Monochromatic Filter.* F. Paschen. (Ann. d. Physik, 48. 6. pp. 858-860, March 20, 1914.)—The author has succeeded in isolating many spectral lines monochromatically in the region around 1μ by using a combination of Wratten and Wainwright's filters F29 (or 28) and H45 (or 44) in conjunction with a 1-cm. water-cell. The combination, cemented between optical glass plates and made watertight by Canada-balsam and tin-foil, is preferably placed inside the water-cell. The region of max. transparency, 60-70 per cent., extends from about 0.85 to 1.15μ .

With a helium lamp 69.3 per cent. of the ray at 1.088μ is transmitted, and with a quartz cadmium lamp 69.5 per cent. of the ray at 1.089μ , whereas, for instance, Wood's infra-red filter transmits only 18 per cent. of the former ray. Several other good combinations can be obtained. C. S. G.

1043. *Developments in the Construction of Periscopes for Submarines.* F. Weidert. (Jahrbuch der Schiffbautechn. Gesell. pp. 174-227, 1914.)—The utility and safety of a submarine depend on the use of a reliable and inconspicuous apparatus making visible more or less of the surrounding surface of the sea to the officer in command, yet the periscope was the last of the essential components of a submarine to be brought to that perfection on which the practicability of effective submarine attack now depends. The author traces the development of various methods and apparatus for seeing the surface from a vessel submerged below the latter. The most rapid and important improvements in periscope design and construction have been made during the last ten or twelve years, and relate to increased field of view; brightness and sharpness of picture; convenience of observation; and the incorporation of range-finding devices. Purely optical improvements have been accompanied by improvements in mechanical design and manipulating gear. The adverse effects of boat and sight-tube vibration and of water on the surface prism or window have been reduced. The author describes and illustrates the construction and use and compares the relative merits and demerits of simple reflecting sight-tubes and bent telescopes of various types. Lens devices alone give a sufficiently large field of view while permitting the use of long and slender sight tubes. In modern apparatus the field of view is increased by bringing the eyepiece optically nearer to the objective. Numerous illustrations show the construction of the light-path in various periscopes. A magnification of 1.5 is found to convey the impression of natural magnitude to normal eyes; a 1:1 ratio leads to distances being overestimated. Special devices giving a magnification of 5 or 6 are used to permit details to be distinguished. A fairly large focal area is desirable in order that as bright an image as possible may be obtained at all times and in order to reduce fluctuations of brilliancy (as seen by the observer) when the apparatus is subject to vibration. About 4% loss is suffered at each surface by reflection of light falling perpendicularly on to clear polished glass; the actual loss as a percentage of the original increases less rapidly as the number of surfaces increases. The reflection loss in a periscope system of the Grubb type may be 57.5 % and more if the glass surfaces be dirty or wet: the absorption loss may be 28.5 % leaving about one-third of the incident light available at the eye-vol. xvii.—A.—1914.

piece. Within limits, expansion of the observer's pupil compensates for this loss. Excessive absorption, blurring by multiple reflection, and cumulative optical errors make it impracticable to employ more than 4 telescope systems in series. The greater part of the sight tube must be of at least that diam. required to prevent vibration and deflection, but the upper portion of tube (projecting above the surface) may be much smaller. The mounting of the ocular and arrangements for erecting and rotating the sight tube are described and illustrated. Means are described whereby rotation of the whole tube may be eliminated ; this operation demands considerable effort owing to the water pressure exerted on the tube when in motion. The direction of sight at any moment is then indicated by a scale and geared pointer visible in the field of view itself. The objective head is usually tested under 10 atmos. water pressure and the ocular head under 1 atmo. external and 10 atmos. internal pressure. Means of removing moisture condensing on the lenses, etc., are described in the original.

The first instrument of the cleptoscope class providing an image on a matt screen was built in Germany in 1908-4. The advantages and limitations of such instruments are discussed. The advantages of a combined "ocular-matt disc" instrument are indicated, and the 1909 Goerz model is illustrated and described. The advantages of rotating-objective bifocal periscopes are compared with those having interchangeable oculars, in providing two or more ratios of magnification : a supplementary telescope may be used. Various panoramic periscopes are described and illustrated in detail. The utility of a Dove prism, in providing an erect image in a stationary eyepiece while the objective is rotated, is explained. Alternatively two confocal cylindrical lenses may be used. Mangin's ring mirror lens is applied to obtaining an annular image of the whole horizon in a single eyepiece : the word "periscope" applied originally to this apparatus alone. Aldis' lens uses a hyperboloid mirror surface to eliminate aberration ; Goerz's spherically-corrected ring-mirror lens is described. The latter provides an annular image of the whole horizon and a central enlarged view of any desired part of the horizon, the whole of both images being visible at the same time. The most serious of the several objections urged against this instrument is the difficulty of determining and changing bearings quickly by reference to the panoramic image, which is greatly distorted. Binocular periscopes offer important advantages and may comprise two independent sight tubes. Small diameter can be preserved in long-tube binocular instruments by using only a single objective and splitting the light received by suitable prisms near the eyepieces ; this halves the light passing to each eyepiece but usually still provides more light than the normal eye can receive. The arrangement and use of a compass card in the head of the sight tube is illustrated and explained ; such a card is useful in taking bearings and as a control over or substitute for the navigating compass. The final section of the paper deals with range-finding attachments. The simplest device is the telemeter plate, which in its most convenient form shows, say, the height of a funnel as a percentage of the range. A more convenient and accurate device is the double-image micrometer by which part of the image can be displaced through its own height with reference to the other part, and the range then read directly on a scale (the actual height of the object being known). R. E. N.

1044. *Refraction of Light in Space Grating*. E. Buchwald. (Phys. Zeitschr. 15. pp. 881-887, April 1, 1914.)—A research is described on the refraction of visible light by a space grating structure which gives an inter-
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ference effect of the type of the X-ray patterns obtained with crystals in Laue's arrangement, *i.e.* similar to an incomplete crossed grating spectrum. Photographs of the effect are reproduced. A comparison of the results of the research with Laue's theory shows that the agreement can only be regarded as qualitative and not in general as quantitative, and no definite conclusions with regard to wave-length and grating constant can be drawn from the photographs. The source of the differences may be sought in the shadowing effect of the refracting particles. [See also Abstracts Nos. 1686 (1918) and 872 (1914)]. A. W.

1045. *Plane Grating*. F. Biske. (Phys. Zeitschr. 15. pp. 827-881, April 1, 1914.)—A paper discussing theoretically the shape of the rulings on a plane grating to concentrate as much energy as possible into a single-order spectrum, also dealing with the energy distribution from the standpoint of the diffraction theory. A. W.

1046. *Refractive Indices of Gaseous Mixtures*. S. Valentiner. (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 863-866, April 15, 1914.)—Describes a fresh examination, by the method of F. Richarz and E. Neumann, of the experimental results found by the author and O. Zimmer [Abstract No. 485 (1914)] for the refractive indices of gaseous mixtures. A brief outline of the method is given. The deviations of the experimental results from those calculated according to the ordinary law are treated in five different ways to provide five values of a function W . If the mean value of W is small the deviations are probably due to accidental error, while as W approaches unity the probability of a true departure from the law increases. In conformity with the conclusions arrived at in the original paper [*loc. cit.*], such true departure was found in the case of a CO_2 -H mixture, but not for the He-Ne-H.

J. W. T. W.

1047. *Interference Experiments in a Rarefied Gas*. F. P. Kerschbaum. (Phil. Mag. 27. pp. 397-415, March, 1914.)—A brief discussion is given of the radiation hypotheses of Planck and Thomson, and an attempt is made to explain from the unit point of view the interference experiments hitherto known. Interference experiments are then described where the source of light and the interference apparatus are in the same highly evacuated vessel. The whole vacuum vessel was made of transparent quartz-glass. A tube 600 mm. in length, 15 mm. internal diam., has a cylindrical ground surface on the outside at one end. Over this ground surface a short brass cylinder fits tightly, and the end of this cylinder is closed by a brass disc bearing a slit which has to act as the line source of light. This slit was 0.02 mm. in width, 12 mm. high and 15 mm. in length. The other end of the quartz-glass tube was provided with two slots, 12 mm. long, 0.05 mm. wide, and 1 mm. apart, cut in a thin sheet of copper; these slits were arranged to give the greatest possible intensity and distinctness to the fringes seen when a source of light was placed behind the first slit. The whole tube was then pushed into another quartz-glass tube, the two fitting with a ground joint, and the double slit just reaching to the end of the outer tube, which was closed with a plane-parallel plate of quartz-glass fused on the tube. The outer tube at the other end had a second ground joint and was attached to a sort of cap whose interior formed a chamber in which resonance radiation of Hg-vapour was produced by a Hg arc-lamp of special construction. The whole apparatus was pumped out with a Gaede pump, and it is believed that the partial

pressure of gas finally left after liquid-air cooling was under 0.000001 mm. A telephoto camera was used for photographing the fringes, and was brought right up to the plane-parallel plate of the vacuum vessel. At the low pressures used no trace could be found of any diminution in number or distinctness or intensity of the fringes produced, compared with the appearance of the fringes given by the same apparatus at atmospheric pressure. The experiments show that we have no reason to assume that a subdivision of light-units is taking place when these units pass through matter. The resonance hypothesis is therefore not able to reconcile the existence of interference phenomena with the conception of units dealt with in the earlier part of the paper. But we are not forced by this experimental result to assume the hypothesis that the energy of the elementary radiator is only spreading in spherical waves, if we can develop a conception of a unit which produces effects similar to those of waves when falling upon an interference arrangement. Such a conception seems possible, and one is suggested based on some ideas of J. J. Thomson. An atom model is assumed with electrons rotating round a central body, lines of force originating from the electrons, and disturbances travelling along them. A line of force originating normally to the plane of rotation of the electron will not have much motion, and a train of oscillations travelling along this line will be in something like a straight line. But on a line of force in the plane of the rotation of the electron, a train of oscillations will not be emitted as whole in a certain direction; if the motion of the electron is only rapid enough the train of oscillations will be emitted in a spiral with a very considerable number of turnings. These spirals spread. As a finite source of light will emit them in random directions, these spirals will produce effects similar to those of spherical waves when falling upon an interference apparatus. From the fact that very distinct interference fringes can be obtained experimentally, we should have to deduce that the energy emitted from a source of light in straight trains is very small compared with the energy emitted in such spirals. These views form, perhaps, the foundation for a combined explanation of the purely optical phenomena and of the ionisation effects. [See also Abstract No. 900 (1911).] A. W.

1048. *Aberration in a Dispersive Medium and Airy's Experiment.* J. Walker. (Phys. Soc., Proc. 26, pp. 82-84, Feb., 1914.)—The view recently adopted by Rayleigh that in the case of aberration we are concerned with the group-velocity instead of with the wave-velocity, makes it necessary to consider the experiment of Airy, in which he measured the angle of aberration with a telescope filled with water. A modification of Rayleigh's explanation of this experiment leads to the result that the angle of aberration thus determined corresponds to an angle $\mu^{-1}v/U$ measured in air. The same result is obtained from an analytical investigation, and a numerical calculation shows that the increase in the angle is about 1 per cent.—an amount that is probably too small to be detected. AUTHOR.

1049. *Interference Images of a Grating Line.* J. Kern. (Phys. Zeitschr. 15, pp. 887-842, April 1, 1914.)—A mathematical treatment; does not admit of brief abstract. [See also Abstracts Nos. 1968 and 1964 (1918).] A. W.

1050. *Formation of Images by Means of an Opaque Disc.* A. W. Porter. (Phil. Mag. 27, pp. 878-874, April, 1914.)—"In spite of the prominence given in treatises on Physical Optics to the existence of the bright spot at the VOL. XVII.—A.—1914.

centre of the shadow formed by a point source and a circular disc, it does not seem to have been recognised that, as ordinarily exhibited, the bright spot is in reality an image of the source of light. The source is never a point in practice, and the contour of the bright patch is simply the locus of the diffraction spots formed by the various points on the contour of the source of light." The author had long been impressed by the very sharp boundary of the bright patch when obtained with a pinhole source, and the explanation recently occurred to him. To test the matter, he took a circular source about 9 mm. in diam., with a thin wire stretched across its centre, illuminated from behind by an electric arc, and found that, as he suspected, the patch was transformed into a sharp image of the bright opening with its dark bar. It is thus possible to obtain sharp images of small objects, using an opaque disc instead of a lens. In conjunction with E. T. Paris, he has taken photographs of a triangular opening, one of which is produced in the original article. The superiority of the optical definition in this case to that in the complementary case of pinhole photography is noteworthy. It would have been impossible to obtain a photograph of the triangle with an aperture of the same size instead of a disc. The length of each side of the triangular source was 0.21 cm., and of the image, 0.58 cm. The author calculates theoretically the size of the true bright spot for a source on, or near, the axis of the disc, and applying the result to the case in question, finds that the side 0.58 of the image is about 40 times as long as the diameter of the calculated bright spot. There is advantage in placing the disc fairly near to the source. A. E.

1051. *Brightness of Optical Images.* P. G. Nutting. (Washington Acad. Sci., Journ. 4. pp. 129-184, March 19, 1914. Photographic Journ. 54. pp. 187-191, April, 1914.)—An abridged paper, in which the author states the formula giving the relative brightness of image and object, for any values of u , v , lens aperture and focal length. Experimental determinations of the relation, using various well-known lenses, are described; by comparing the results with the formula the percentage transmissions of the lenses are deduced.

T. H.

1052. *Stereoscopic Effects without a Stereoscope.* (Science, 89. pp. 17-18, Jan. 2, 1914.)—A background is prepared so as to scatter light in such a way that it appears white to the one eye, black to the other, when the observer takes up a proper position. On this are superposed two film images, the one a positive transparency, the other a bleached negative. To the one eye the one of these is invisible, to the other the other. The effect of what is seen is a blend in stereoscopic relief.

A. D.

1053. *Control of Photographic Tone-values.* A. Kapteyn. (Photographic Journ. 58. pp. 285-296, Dec., 1918.)—To use a negative which presents contrasts beyond the grasp of the printing process employed, supplement it by putting on the negative a perfect positive image, obtained by contact and placed in true contact with it. Practical difficulties as to registration and as to the optical consequences of imperfect contact, and how to overcome these, are dealt with. Applications to cases of difficulty are discussed.

A. D.

1054. *Speed of Plates; Testing by Daylight.* W. B. Ferguson. (Photographic Journ. 58. pp. 297-307; Discussion, pp. 307-308, Dec., 1918.)—A practical approximate method, applicable to colour-sensitised as well as

ordinary plates, of ascertaining relative speeds by comparing the apparent inertias on a Hurter and Driffeld diagram. As an equivalent for daylight it was found that an 8-c.p. Osram lamp, run at 10 volts, with a Wratten's No. 79 light-filter gave what was required. A. D.

1055. *Direct Photographic Positives.* G. A. Perley, T. J. Twomey, and H. A. Robinson. (Journ. Phys. Chem. 18. pp. 185-212, March, 1914.)—The conditions for the best direct positive by development are critical, and slight variations cause either fog or a negative. The critical conditions are found for a large number of practical cases. Example: Imperial special lantern plate; exposure through a lantern-slide of average density, 8 seconds at 18.5 in. from a 15-c.p., 6-volt tungsten lamp worked at 2.5 volts; temperature 20-21°C.; development 2 to 2½ minutes in the following: water 9.8 gm., sodium sulphite 0.284, hydroquinone 0.084, allylthiocarbamide 0.0014, sodium hydroxide 0.0026, all in gm. per sq. in. of surface: result, an excellent positive of purple colour. A great range of tints is obtainable by using different developers. The type of thiocarbamide employed makes a great difference; apparently the unexposed portions of the emulsion are more soluble than the exposed, and are locally dissolved and locally reduced by the thiocarbamide to coloured colloidal silver before an excessive negative can be developed. A. D.

1056. *Light-emission Model.* E. Gehrcke. (Phys. Zeitschr. 15. pp. 128-127, Feb. 1, and pp. 198-201, Feb. 15, 1914.)—Lenard some time ago put forward the view that the light of phosphorus was produced by an electron shot out from the atom a considerable distance and then oscillating about its old equilibrium position. Recently N. Bohr has succeeded in formally deriving a series formula. The present author seeks to obtain this result by a simpler way. For this purpose the following general assumption is made: If an electron through any cause possesses, relative to the nucleus of the atom, the kinetic energy $\frac{1}{2}mv^2$, and if this energy is expended on the generation of ν vibrations per sec., then shall we always have the relation $\frac{1}{2}mv^2 = h\nu$. This relation is apparent and fairly well established from the experiments on the secondary electron rays from ultra-violet light, Röntgen-rays and γ -rays; whether it involves a notable contradiction of the classical mechanics and electrodynamics is a question that need not be further considered here.

Secondly, the author assumes that the electron has a position of stable equilibrium at a distance r_1 from the positive nucleus, being pulled in from positions of greater distance and prevented from coming infinitely near to the nucleus.

Further, the return of the electron to this equilibrium position r_1 cannot commence from any and every distance but only from certain determinate distances r_2, r_3, r_4, \dots . These distances are connected with each other by a certain small distance r_0 such that $r_p = p^2 r_0$, where p is any integer. Thus $r_1 = 4r_0$ and $r_2 = 9r_0$. The equation for the frequency is then derived in the form $\nu = (2\pi^2 mc^2/h^2) [1/9^2 - 1/p^2]$ which gives the Balmer series in agreement with Bohr.

It is further shown that this model atom agrees with the effect of an electric field on the spectrum lines recently observed by J. Stark [Abstract No. 286 (1914)]. It would also show the Zeeman-effect on the Lorentz theory.

E. H. B.

1057. Model of Light Emission. E. Gehrcke. (Phys. Zeitschr. 15. pp. 844-848, April 1, 1914.)—Discusses a model atom in which the electrons are arranged in a number of orbits, each set of orbits occurring on the surface of a given sphere. Thus there are 8 such orbits on an inner sphere, 5 orbits on an intermediate sphere, and 8 orbits on an outer sphere. By this model it is sought to account for the series lines of the spectrum. [See preceding Abstract.] E. H. B.

1058. Intrinsic Optical Activity. G. H. Livens. (Phil. Mag. 27. pp. 468-478, March, 1914.)—There are three possible forms of the electron theory of the intrinsic optical rotatory power found to be associated with certain substances: the first is that given by Drude in his "*Optik*," the second is a mixture of this one and the third, which latter was developed by the author following a suggestion from Lorentz. The object of the present paper is to decide between the three. After making this examination the author concludes that the test of reality results entirely in favour of the third theory, and the formula deduced from it may therefore be taken as best representing the facts. E. H. B.

1059. Kathodic Decomposition of the Fourth Line of Balmer's Series and Probable Regularities. A. Lo Surdo. (Accad. Lincei, Atti, 28. pp. 826-828, March 1, 1914.)—The author extends his previous observations [Abstract No. 666 (1914)] to the fourth line, H_δ , of Balmer's series, which lies so far towards the violet end of the spectrum that the method of direct vision was replaced by a photographic method. The mercury-vapour from the pump was prevented from entering the observation tube by the insertion of a condenser cooled in liquid air, and a displaceable cathode was employed so that it could be used for a number of photographs. Several lines due to impurities make their appearance, but these cannot be confused with the decomposed elements if an image of the tube placed parallel to the slit is projected on to the latter. The decomposed elements exhibit their max. separation near the cathode and gradually reunite as the intensity of the electric field diminishes. They have therefore a fan-shaped configuration, which permits of their certain distinction from other non-inclined lines and also indicates the line from which they originate. The results obtained with the four lines are given in the following table, which shows their relation to the rule expressed by Balmer by the equation, $1/\lambda = a - 4a/n^2$, which for $n = 1$ or 2 gives results which cannot be interpreted, but for $n = 3, 4$, etc., gives the wave-lengths corresponding with the terms 1, 2, 3, etc.:—

Line	H_α	H_β	H_γ	H_δ
λ	6562.1	4860.7	4840.1	4101.2
n	3	4	5	6
Total number of components	8	4	5	6
Order of line in series	1	2	3	4
Components with normal vibrations	1	2	3	4

T. H. P.

1060. Decomposition of the Red Hydrogen Line in the First Kathodic Layer. L. Puccianti. (Accad. Lincei, Atti, 28. pp. 829-830, March 1, 1914.)—The author confirms the results obtained by Stark [Abstract No. 238 (1914)] and by Lo Surdo [see Abstract No. 666 (1914)] for the lines H_α , H_β , and H_γ [see also preceding Abstract]. T. H. P.

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1061. *Comparison between the Kathodic Decomposition of the First and that of the Second Line of Balmer's Series.* L. Puccianti. (Accad. Lincei, Atti, 28, pp. 831-833, March 1, 1914.)—The author finds that, if the separations of the extreme components produced by cathodic decomposition of the lines H_α and H_β are represented by $\Delta\lambda_\alpha$ and $\Delta\lambda_\beta$ respectively, these magnitudes are connected by the simple relations, $\Delta\lambda_\beta/\Delta\lambda_\alpha = 8/2$ and $(\Delta\lambda_\beta/\lambda_\beta) : (\Delta\lambda_\alpha/\lambda_\alpha) = 2$. These relations cannot both be rigorously true, since the value $8/2$ for the former would give $81/40$ for the latter. T. H. P.

1062. *Absorption of Light by Uranous Chloride in Different Solvents.* T. R. Merton. (Chem. Soc., Journ. 116, pp. 28-27, Jan., 1914.)—Marked changes are produced in the spectrum of uranous chloride by the addition of hydrogen chloride to its solutions in different liquids. These phenomena cannot readily be explained without assuming that different kinds of aggregates coexist in the solutions, and that the vibrators responsible for the less refrangible bands are situated in different aggregates to those responsible for the more refrangible bands. T. M. L.

1063. *Spectrum Lines for Monochromatic Illumination.* R. W. Wood. (Phil. Mag. 27, pp. 524-530, March, 1914. Phys. Zeitschr. 15, pp. 818-817, April 1, 1914.)—In order to obtain pure monochromatic illumination of great intensity the author adopts a polarisation method which allows one or more lines to be removed from a spectrum with practically no loss of light. Instead of nicols two double-image prisms are used in conjunction with a Dunoyer condenser, between the halves of which a large quartz plate is placed. This plate must be between 25 and 40 mm. in thickness, and, for sodium light, plane parallel to considerably within 0.082 mm. By this arrangement it is possible, for instance, to obtain a focus (1×8 cm.) of one or other of the D-lines at will by suitably rotating the quartz plate. Brazilian quartz alone appears to have the necessary optical purity for making a suitable plate. C. S. G.

1064. *Intense Sodium Flame.* R. W. Wood. (Phil. Mag. 27, pp. 530-531, March, 1914.)—A sodium flame with an intensity approximating to the oxy-hydrogen sodium flame is produced by using a few pieces of the fused chloride on a fragment of a Welsbach mantle placed on the grill of a Méker burner. C. S. G.

1065. *Different Spectra of Mercury, Cadmium, and Zinc.* J. de Kowalski. (Comptes Rendus, 158, pp. 788-789, March 16, 1914.)—The same metals under different discharges are known to give different spectra. A method is described by which all the different spectra can be reproduced in the same experiment. A luminous discharge is produced in the vapour of the metal contained in a quartz tube by means of copper wires, carrying high-frequency current, wound round the tube. The metal is contained in a bottom annex and the pressure of its vapour is altered by heating this. At high pressures (< 10 mm.) isolated discharges take place due to the electrostatic effect of the field, but at low pressures these change into annular discharges in consequence of the electromagnetic action of the current. The luminosity is feeblest for Cd and greatest for Hg, and when analysed consists of a faint continuous spectrum interspersed with brilliant lines of the ultimate spectra. Different lines appear at different pressures. On further lowering the pressure the annular discharge increases greatly in brilliancy, and between

narrow limits splendid band spectra make their appearance. In Hg-vapour these appear below 0.2 mm. and are very rich in lines; they cannot be attributed to impurities.

The vapours of Cd and Zn, like that of Hg are found to fluoresce under the action of the X-rays when their density is about equal to that which in an electromagnetic field would produce a continuous spectrum. Fuller measurements will be published later.

C. S. G.

1066. Structure of the D_1 and D_2 Lines observed in a Bunsen Flame with different Sodium Compounds. K. I. IVANOV. (Russian Physico-Chemical Soc., Journ. 45. pp. 125-141 [Physical Part], 1918. In Russian.)—The classic way shown by A. A. Michelson [Phil. Mag. 84. p. 280] is correct only when the intensive curves are symmetrical in relation to the middle of the line, which does not happen in very many cases, and the use of a thermo-element for this purpose is a very difficult matter. The aim of the present investigation was to find if on the basis of a correct structure of D-lines, received by the use of Koch's and Brotherus' method [Abstracts Nos. 759 (1911), 1858 (1912)], it would be possible to determine whether the sodium lines are constant or not. When the brightness of a yellow light is observed it is only necessary to use, first NaBr, and next Na_2CO_3 in a Bunsen burner; and it will be found that in the former case the light is brighter. For the examination of the spectrum the author used a large flat Rowland grating (12.7×9 cm.) having about 14,000 lines to the inch; telescope, 280 cm. long; diam. of object-glass, 8.2 cm. A lens of 5.5 cm. focus was used to reflect the light on to the slit of the spectroscope (height, 1 cm.). The separation of the D-lines on the sensitive plate in the spectrum of second order was 5.8 mm. To measure photometrically the absorption lines he used Hartmann's microphotometer, and the mirror enclosed in the glass tube gave a surface of 0.600×0.084 mm.² on the plate. The scale of intensity was established by the method of Voigt (Brotherus loc. cit.). This intensity of light changes from bright to dark streaks according to law best expressed by the formula $i = i_0 \cdot \cos^2 \pi x / l$. As photographic plates taken from the same packet often differ in sensitiveness it was necessary to compare all the spectral lines on the photograph, on one plate, with a scale of intensity; and as only 6 spectra could be taken on one plate he used the following: NaI, NaBr, NaCl, NaNO_3 , Na_2CO_3 . Wratten and Wainwright panchromatic plates were used, the exposure given being 8 hours. Though the spectroscope was protected from outside light and diffusion was possible only through the slit—which in all tests, when it was desired to arrive at constant intensity in the D-lines, was 0.081 mm. wide—the experimental room was kept in perfect darkness. The plates were developed in the usual manner. During the long exposure it was important that the burner should not only burn perfectly, but that no change should take place in the adjustment. For this reason the temperature of the air near the spectroscope was constantly kept under observation, both before and after exposure. The Na salts were introduced into the flame as solutions, and these were used as concentrated as possible; thus NaI, 82.8 %; NaBr, 22.8 %; NaCl, 12.6 %; NaNO_3 , 18.5 %; Na_2CO_3 , 11.5 %. Having regulated the stream of air and gas into the burner at 2.5 m. per min. a flame was obtained in which, through the insufficiency of air, combustion was imperfect and extension reduced. The intensity of the D-lines was so weak that a very long time would have been required to obtain measurements of the blackening on the plate. It was necessary to widen the slit to 0.1 mm.; but in this state

it was hardly possible to obtain a photograph giving a true distribution of the intensity in the D-lines. One experiment gave the maximum intensity as below :—

	D ₁	D ₂
NaI	54.4	45.5
NaBr	46.0	41.0
NaCl	42.4	36.4
Na ₂ CO ₃	40.7	33.8

When these results are compared with Thomson's tables (Landolt-Börnstein, p. 484, 1905) which give NaI, 69.1; NaBr, 85.7; NaCl, 97.7; Na₂CO₃, 272.6, we can see that in flames with a low temperature the more solid compounds give a weaker light. The thermal conditions then govern the emissive power of the D-lines. A more generous supply of air was then given to the burner, and in order that the amount of sodium should remain near that first used the solutions were so diluted that instead of 5 % they contained only 3 % of Na. These differences in the usual type of Bunsen burner can only be ascribed to differences of temperature in the flame. A Mekerof lamp gives a flame with a constant temperature which is a little higher than that of a Bunsen burner. The same amount of air (6 litres per min.) was allowed and of Na (0.078 mgm. per sec.); lighting gas used was only 1.9 litres per min. During the whole length of burning the temperature was 1720° C. The lines obtained with the different salts of sodium were alike.

The author arrives at the conclusion that there are two probable explanations : (1) That the atoms of Na form the D-lines only during the very short time that they are free ; or (2), what is more probable, that the system by which the D-lines are formed is inherent in the Na-atom itself : that molecular combinations have no influence over the structure of D-lines. This phenomenon still requires a satisfactory theoretical explanation. I. P.

1067. *Spark Spectra of Nickel and Cobalt in the extreme Ultra-violet.* L. and E. Bloch. (Comptes Rendus, 158. pp. 784-787, March 16, 1914.)—The spark spectra of these metals in the region 2800 to 1850 Å. is obtained with a quartz spectrograph on plates specially sensitised according to Schumann's directions. The lines are read with a dividing machine in International units, using the Cu and Al lines in this region as the comparison spectra. An accuracy of about 0.1-0.2 Å. is obtained throughout. Discussion of the spectra is reserved till later. C. S. G.

1068. *Arc and Spark Spectra of Tin.* R. Arnolds. (Zeitschr. wiss. Phot. 18. pp. 818-831, March, 1914. Extract from Dissertation, Bonn, 1913.)—The arc and spark spectra of tin are remeasured photographically on the International unit basis (red Cd line) between $\lambda 7800$ and $\lambda 2069$ by means of a Rowland grating, and are compared with former measurements. The lines show a very good agreement with values calculated on the Kayser and Runge basis but conform indifferently to those calculated from van Lohuizen's formula. C. S. G.

1069. *New Determination of Optical Parameters in the Case of the D-lines.* K. I. Ivanov. (Russian Physico-chemical Soc., Journ. 45 pp. 109-124 [Physical Part], 1918. In Russian.)—Voigt in his "Magneto- und Elektro-optik" (p. 108) has put forward a method in which the "width" of the streaks is estimated at 2 μ . This method, however, on a more reliable VOL. XVII.—A.—1914.

photometric determination of the width of the absorption lines does not give us the expected sizes of V' (one of Voigt's parameters), and the author hence gave up the idea of using it to determine V' .

Take a flame of unit thickness upon which a light impinges from somewhere, giving a continuous spectrum, its intensity in the region of the investigated line being constant and equal to I . The weakened intensity from absorption being designated i , we receive then $-4\pi/\chi f'_0 n x dz$, $i = Ie = Ie^{-\rho}$. For every stratum of nx the bulk nx is falling off from the maximum determination $nx = \rho/2n_0V_0V'$ to a half; if away from the middle of the streak, to $\mu = \frac{1}{2}V'$. If V' was constant for all layers of the flame, it would mean $\mu = 0$ and $i = i_1 = Ie^{-\rho} \dots$, where $\rho = 4\pi/\chi f'_0 n x dz$; the opposite of this $\mu = \frac{1}{2}V'$, $i = i_2 = Ie^{-\rho}$; and we would obtain the following equations: $i_1/I = (i_2/I)^2$, $i_2 = V_1 I$. The second equation enables us to find V' when the distribution of the intensity in the absorption band is photometrically measured. It is sufficient to find two points of intensity i_2 on the curve; the distance between them gives V' .

Since the magnetic field into which the flame is placed to determine ρ may deform it, the author states that when the non-polarised white light passes through in the direction perpendicular to lines of coloured flame in the magnetic field he received instead of one streak with a density V_1 two absorbing streaks with densities of $V_0 \pm \mu_0$ and the determinations are $i_1 = I/2(1 + e^{-\rho})$ and $i_2 = I/2(1 + e^{-\rho})$; which makes $i_2 = I/2 + \sqrt{(i_1 - I/2) \cdot I/2}$. In the observations of the magnetic rotation of the plane of polarisation he used NaI, NaBr, NaCl, NaNO₃ and Na₂CO₃, all containing 5 % of Na. To test the dependence of \bar{V}' on the density of steam he introduced into the same flame solutions of NaBr containing 5 %, 5/2 %, 5/4 %, 5/8 %, 5/16 % Na. Definitions of \bar{V}' were as follows: 40.2×10^{10} ; 86.0×10^{10} ; 80.5×10^{10} ; 22.7×10^{10} ; 15.5×10^{10} instead of the expected values 48 : 85 : 28 : 22 : 17. n_0 may be in all tests of this kind taken as unity. To measure χ and μ the author used a microscope of small magnification, which could, with the help of two micrometric screws, be turned into two perpendicular positions. Three points were chosen in each crook, and the distances measured to an accuracy of 0.01 mm. from the primary middle of the absorption band and interference streak. The first distance gave μ , and the second χ . In the case of NaBr it was found that $\bar{\rho} = 6.27 \times 10^{13}$. With NaI, NaCl, NaNO₃, Na₂CO₃, the average for Na salts was $\bar{\rho} = 6.88 \times 10^{13}$. In all cases where the value of V' is ascertained by photometric instead of optical processes [which were used by Hallo and by Geiger. Abstract No. 2040 (1907)] the numbers in definition were higher. In this way the dimension of \bar{V}' is correctly ascertained within 2 to 8 %. Taking $\mu = 0$, $\rho = 88 \times 10^{13}$, $V_0 = 8.2 \times 10^{15}$, $\bar{V}' = 40.5 \times 10^{10}$, $n_0 = 1$ we find the maximum dimension of nx_m defined as $nx_m = \rho/2n_0V_0\bar{V}' = 2.4 \times 10^{-4}$ and by the use of the formula $\delta = \bar{V}'/2 \cdot \bar{i}$, we find the decrement of δ for flames containing respectively the greatest and smallest quantities of Na to be—

$$\delta_M = 8.9 \times 10^{-4}; \delta_m = 1.5 \times 10^{-4}.$$

I. P.

1070. *Effects of Electric and Magnetic Fields on Spectra.* N. Bohr. (Phil. Mag. 27. pp. 506-524, March, 1914.)—After summarising the main outlines of his theory of atomic structures [Abstracts Nos. 15 and 811 (1914)], the author shows how it suggests explanations of Stark's recent discovery [Abstract No. 288 (1914)] and of the Zeeman-effect. On this theory an electric field may be expected to influence the stationary states of an atom, e.g. H, and therefore its energy in these states, but not the mechanism of transition

between the states. Assume a nucleus of infinite mass compared to that of electron, and let an electron orbit be originally circular, but deformed by an electric field. The effect in time of even small electric force, unless accurately perpendicular to the orbital plane, will be considerable. At any instant the orbit may be regarded as an ellipse with the nucleus as focus, and the field effect as gradual variation of direction of major axis and of eccentricity, during which the length of the major axis will remain approximately equal to the diameter of the original orbit. Two stationary orbits are then found possible, consisting of a straight line on either side of the field axis and parallel to it, and orbits near these limiting cases are found to be nearly stationary. A formula is then found holding for high values of n , where n_1, n_2, \dots are the whole numbers in the equation $f_r(n) = K\phi_r(n)/n^2$ which, according to Balmer, Rydberg, and Ritz, expresses the frequency of the lines in the line-spectrum of an element, K being a universal constant, and ϕ a function which for large values of n approximates to unity. For the mechanical interpretation of the calculations it is then merely necessary to assume that the eccentricity is very nearly unity for large orbits, which formula gives for every H-line two components placed symmetrically with regard to the original line, their difference of frequency being given by the equation $\Delta\gamma = 8hE(n_1^2 - n_2^2)/4\pi^2 cm$, where E is the external electric force, n_1 and n_2 are the values of n for two successive stationary states, m and $-e$ are the mass and charge of the electron, and h is Planck's constant. Substituting the experimental values of the constants results in satisfactory agreement with Stark's experiments being obtained. Stark's observation of the field effect on the lines of the different series of the spectrum seem also to receive simple explanation. For any element the different series correspond (on theory) to series of stationary states in which one electron moves in an orbit outside the others. The nearer $\phi_r(n)$ approaches unity the less is the disturbance due to the inner electrons and the more closely does the motion of the outer one approach to that of the H-atom electron. Now for He and Si, being elements of low atomic weight, $\phi_r(n)$ is nearly unity for the Diffuse series, but not so nearly for the Sharp series or Principal series, so that the field should have much greater effect on the first series, as Stark found. The Diffuse He series would here correspond to transition between two stationary states, one affected, the other unaffected, by the field, while for H both states would be affected. This might account for Stark's observation that the components were not (as for H) polarised relatively to the field.

In the case of a magnetic field, to obtain the connection with the ordinary mechanics and also to agree with experiment, the author's conclusion is that the field effect on the stationary states of the H-atom is simply a superposed rotation of frequency τ round the axis of the field, and that the transition radiation is so changed by the field as to have the polarisation and frequencies of a Zeeman triplet. The assumption is equivalent to supposing that the energy of the H-atom in its stationary states is unaffected and that the previously assumed relation $h\gamma = A_1 - A_2$, where A_1 and A_2 are the energies in two successive states, is, in case of vibrations perpendicular to the magnetic field, replaced by $A_1 - A_2 = h(\gamma \mp \tau)$. A possible explanation of the complex Zeeman-effect of double lines is indicated on this basis. G. W. DE T.

1071. *Effect of Electric Field on Spectrum Lines.* J. Stark and H. Kirschbaum. (Ann. d. Physik, 48. 7. pp. 1017-1047, April 2, 1914.)—A continuation of previous work [see Abstract No. 288 (1914)]. A detailed description is given of the electrical method employed to cause the atoms of
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various substances to emit light in the canal rays, and particulars are given of the concave-grating apparatus used. The series lines of H, He, and Li were investigated, together with lines of Na, Mg, Ca, Al, Tl, and Hg, and the band spectra of H and N. The results are tabulated. The series laws are discussed in relation to the effect of the electric field, as are also (i) the broadening of series lines due to increased current and vapour density, and (ii) the pressure shift of spectral lines. A. W.

1072. *Origin of Spectra.* R. J. Strutt. (Nature, 98, p. 82, March 12, 1914.)—It has been known for some years that a stream of luminous vapour can be distilled away from the mercury arc *in vacuo*, the vapour still remaining luminous when it has passed far beyond the limits of the electric field. This luminosity is quenched when the stream passes near a negatively electrified metal surface. The author has now succeeded in extending these results to other, less volatile metals. The present paper gives a preliminary account of some of the more significant observations. In the case of sodium, under favourable conditions a very curious behaviour is observed. Where the distilled luminous vapour leaves the lamp, the light is yellow and is dominated by the D-lines. Farther on it becomes green, and the lines of the two subordinate series outshine the D-lines. Finally, farther still, the D-lines again predominate. Another interesting effect is seen when the luminous stream is made to pass through a negatively electrified wire net. As in the case of mercury, the glow is partially extinguished; but spectroscopic examination shows that the lines of the subordinate series are far more affected than the D-lines. Whatever view be taken of the origin of the distilled glow, this latter experiment shows that the systems which give rise to the subordinate series are not the same as those which give rise to the principal series. In the case of potassium, the development of the subordinate series in the distilled glow is very striking, and the existence of a series relation between the lines is visible at a glance, since the series are not confused by extraneous lines. The photography of this spectrum will be undertaken, and it is hoped this will lead to an improved knowledge of the series and their convergence point. With magnesium, the colour initially is green, dominated by the triplet *b* and the green band of the "magnesium hydride" spectrum, upon which as a background *b* lies. As the vapour moves on these die out, but the blue flame line $\lambda 4571$ survives much longer. On passing the vapour through a wire gauze at -40 volts, all the features of the spectrum which have been mentioned were found to diminish in intensity, but the effect on the blue line and on the bands of magnesium hydride was much stronger than the effect on *b*. The extinction of the band spectrum of the hydride is specially significant. Experimental details, and a discussion of the origin of the distilled glow, will be given in a subsequent paper. A. W.

1073. *The Transfer of Energy of Motion in the Excitation of Light by Canal Rays.* W. Wien. (Ann. d. Physik, 48. 6. pp. 955-964, March 20, 1914.)—Up to the present, experiments on the alteration of velocity in the path of canal rays have only produced negative results; no diminution of the velocity has been proved. From this it follows also that only a small transfer of kinetic energy takes place to resting gas molecules from such canal-ray atoms as are not absorbed. In the present experiments great dispersion is obtained with a grating in order to ascertain whether the spectral lines excited by canal rays show any increase in width as might be expected according to Doppler's principle and the small alteration of velocity. The results throughout are of

a negative nature. The experimental details are given, and the results shown graphically. From the negative nature of the results it is concluded that with the excitation of the observed spectral lines, at least with the greatest portion of the emitted rays, the collisions are effective in which there is no considerable transfer of velocity. This is in agreement with the assumption that those collisions which bring about the recharging of the atom also cause the emission of light.

A. E. G.

1074. Dynamical System Illustrating Fluorescence. N. P. McClelland. (Cambridge Phil. Soc., Proc. 17. No. 4. pp. 321-322, Jan. 30, 1914.)—The characteristic feature of the phenomenon of fluorescence is that the period of the exciting force differs from that of the induced vibration. No simple dynamical system appears to have been brought forward hitherto in which this condition is fulfilled, consequently it appeared of interest to suggest the following, which is founded on a well-known model of the atom. Suppose a particle of unit mass revolves in a circular orbit about a fixed point, there being no resistance to the motion, but that forces exist which damp vibrations along the radius vector. The law of attraction here taken is that of the inverse square, but a similar result would be obtained under any law permitting stable motion. This system is then supposed acted upon by a periodic force in its own plane, the disturbance being small. It is then shown that the system responds in such a way as to send out two trains of waves of different period, and these do not combine to give a single train of the same period as the initial disturbance.

E. H. B.

1075. Photometric Study of the Fluorescence of Iodine. R. W. Wood and W. P. Speas. (Phil. Mag. 27. pp. 581-588, March, 1914. Phys. Zeitschr. 15. pp. 817-821, April 1, 1914.)—A continuation of previous work on the effect of admixture with other gases upon the fluorescence of iodine-vapour [see Abstracts Nos. 469, 470 (1911)]. In this investigation the effect of the iodine vapour itself at different pressures on the fluorescence is worked out. The relationship between the temperature and the intensity is first determined photometrically by viewing end-on a tube illuminated axially by the focused beam of a quartz mercury arc. The temperature is varied from -80° to 75° and a max. intensity occurs at $20-25^{\circ}\text{C}$. (Temperature-Intensity Curve). Another curve showing the total fluorescence radiation of *all the molecules* is then obtained by combining these results with the pressures of the vapours at the various temperatures, and the curve exhibits a maximum at 0.2 to 0.8 mm. pressure. From these two curves it becomes possible to construct a third curve showing the decrease of intensity of a *constant number* of iodine molecules by iodine-vapour. The vapour has a measurable fluorescence at -80°C ., and the results show that the non-fluorescing molecules begin to reduce the intensity of fluorescence when the pressure rises to 0.015 mm. The intensity is reduced from 100 to 19 by these molecules at a pressure of only 0.4 mm., whereas the similarly effective pressures for other gases are H_2 , 24 mm.; air, 11 mm.; CO_2 , 7 mm.; ether-vapour, 8 mm.; iodine chloride, 1.8 mm.

It is probable that chlorine is still more effective than iodine in reducing the intensity on account of its electro-negative character. In the case of bromine vapour the destroying action is so powerful that it is only possible to observe fluorescence at about 0.001 mm., or -80°C . The fluorescence spectrum is discontinuous, and some of the observed decrease in intensity, as well as the change in colour from red with the denser vapour to greenish

yellow with the cooler vapour, is due to the selective absorption of the interfering molecules. This absorption is stronger at 0° than at room temperatures. No trace of purely surface fluorescence is observable.

C. S. G.

1076. *Photometry of Luminescence.* F. v. Hauer and J. v. Kowalski. (Phys. Zeitschr. 15. pp. 822-827, April 1, 1914.)—A monochromator for ultra-violet light and a spectrophotometer for dealing with weak sources of light are described. The use of these instruments for various purposes is considered. It is shown that the distribution in the momentary bands given by the phosphorescence of phenanthrene may be separated from the persistent bands. These latter only appear when the excitation falls within the region of the selective absorption of phenanthrene. The maximum of the fluorescence of Li-K-platinocyanide lies at about 890 $\mu\mu$ and decreases towards the ultra-violet end of the spectrum. Excitation of the fluorescence of Rb-platinocyanide by different sources gives different positions for the max. intensity of the fluorescence band. With light of wave-length $\lambda 4047$ the max. intensity is at about 470 $\mu\mu$. The effect of temperature was considered in relation to the persistent phosphorescence bands of samarium-calcium phosphide. It was found that the max. intensity of two different phosphorescence bands occurred at nearly the same temperature—about 170°. But the temperature coefficients of the intensity are not the same for different bands, and in consequence a colour variation may be observed in the total radiation. The velocity of the decay of the phosphorescence increases in general with the temperature, though this increase is different for different bands, and hence in the decay also a variation of colour can be seen. The phenomena dealt with can be estimated quantitatively by means of the photometer to within about 6 %.

A. W.

1077. *Distribution of Scattered Röntgen Radiation.* H. A. Wilson. (Phil. Mag. 27. pp. 888-886, Feb., 1914.)—On the electromagnetic pulse theory of the X-ray, the author derives a formula for the distribution of the scattered Röntgen radiation round a radiator containing elements of small atomic weights. It is now well established experimentally that the intensity of the scattered radiation on the emergent side is greater than that on the incident side of the radiator, and that the distribution on the incident side is given by $I_\theta = I_{\pi/2}(1 + \cos^2 \theta)$, where θ is the angle between the scattered radiation and the incident primary radiation. Recent work on the diffraction of X-rays by crystals has been explained by supposing the rays to be reflected by planes in the crystal which contain a regular periodic distribution of atoms. Metals in the solid state consist largely of small crystals arranged in an irregular manner. We may therefore suppose that the scattered radiation from a metal plate must be due partly to internal reflection from an immense number of small crystals oriented at random, and partly to scattering by the amorphous portion of the metal. On this assumption the following formula for the distribution is obtained: $I_\theta = A[(1 + \cos^2 \theta)/\cos \frac{1}{2}\theta] + B(1 + \cos^2 \theta)$, where A and B are constants and θ is the angle between the scattered radiation and the incident radiation. In this formula the first term represents scattered radiation due to crystals, and the second, that from the electrons distributed at random. When A is put equal to B, the values for I_θ obtained from the formula agree very closely with the experimental values of Crowther. In this case half the scattering electrons are in crystals, and half distributed at

random. The excess of scattered radiation on the emergent side seems, therefore, to be easily explained on the theory that Röntgen rays are very short electromagnetic waves or pulses.

E. A. O.

1078. *Interference of Röntgen Rays and Heat Motion.* P. Debye. (Ann. d. Physik, 48. 1. pp. 49-95, Dec. 81, 1918.)—The author gives various calculations relating to the theory which indicates that heat motion in the atoms has an essential influence on the interference phenomena observed with Röntgen radiation. The interference intensity decreases exponentially with respect to heat motion (a) with increasing angular distance between incident and observation direction, (b) with increasing temperature, (c) with decreasing wave-length. The exponent of the exponential function vanishes when $T = 0$ with failing null-point energy and maintains a finite value when a null-point energy exists. The exponent is inversely proportional to the square of the wave-length. The interference intensity is accompanied by a dissipation intensity which is most intense where the interference intensity appears most feeble, and *vice versa*. The course of the phenomenon can be calculated when data are forthcoming on the behaviour of the specific heat as function of the temperature. A law of similarity holds as with the specific heats of monatomic bodies, according to which the course of temperature is a function of the relation of the characteristic temperature to the temperature of observation.

J. J. S.

1079. *Röntgen-ray Reflection.* C. G. Darwin. (Phil. Mag. 27. pp. 815-888, Feb., 1914.)—This is a first approximation to a mathematical theory of reflection of Röntgen rays, assumed with W. L. Bragg [Abstract No. 989 1918]) to consist in reflection from a set of parallel planes of atoms on the model of the experimental arrangement which has hitherto proved most fruitful, reflection from planes parallel to an external face of the crystal. The ordinary laws of electromagnetic theory are assumed, with a somewhat less satisfactory supplementary assumption. The observed exponential absorption of homogeneous rays is probably a statistical effect, but it is here assumed that the amplitude of a wave passing through matter diminishes exponentially with an absorption coefficient half that observed for the intensity. This gives the correct form for the absorption, and is to a certain extent experimentally justified by an experiment by Moseley and Darwin [Abstract No. 1888 (1918)]. The assumption that scattering and absorption are proportional made in the paper referred to cannot be maintained, the abbreviated proof given being unsound, and they are here taken as independent.

After discussing the lines photographed by Moseley in his method of finding the X-ray spectra of the elements, the intensity of reflection is found both for monochromatic and for heterogeneous radiation, the results being compared with Moseley and Darwin's experimental results with rock-salt. The reflection observed is, however, greater than that calculated, showing the theory to be inadequate in some particulars. The wave scattered by one atom is found to disturb the vibrations of the others. The existence of a refractive index for both crystalline and amorphous substances is indicated by the theory. The "excess radiation" observed in the scattering of X-rays at small angles by amorphous substances [Abstracts Nos. 618, 1168 (1911)] is accounted for by the theory as an effect of the several electrons in an atom. The correction for the temperature vibration is calculated.

G. W. DE T.

1080. *Spectra of Röntgen-ray Beams emitted by Antikathodes of Copper, Iron, and Gold.* M. de Broglie. (Comptes Rendus, 158. pp. 623-625, March 2, 1914.)—The author gives the lines in the spectra of copper, iron, and gold, photographed by a method previously described [see Abstracts Nos. 248, 244 (1914)]. The results obtained are included in the following table—

Anti-kathode.	Rays.	(α = Complement of Angle of Incidence.)	Sin α .	Remarks.
Cu.....	End of intense band.....	4° 9'	0.0857	—
	End of clear band.....	9 8	0.1622	—
	Ray, medium intensity.....	9 7	0.1679	—
	Ray, medium intensity.....	10 0	0.1740	—
	Ray, intense	14 8	0.2462	—
	Ray, intense	15 8	0.2728	—
Fe.....	End of intense band.....	9 1	0.158	—
	End of clear band.....	15 2	0.262	Ni (?)
	Ray, broad medium intensity	16 9	0.295	Ni (?)
	Ray, medium intensity.....	18 0	0.309	—
	Ray, very intense	19 9	0.340	—
Au.....	End of intense band.....	4 9	0.0850	Cu (?)
	End of clear band.....	9 5	0.165	Cu (?)
	Ray, fairly intense	11 0	0.191	A (doublet)
	Ray, fairly intense	18 0	0.228	B
	Ray, intense	14 4	0.248	C (Cu)
	Ray, very intense	15 9	0.274	D (Cu)
	Ray, feeble.....	17 2	0.295	—
	Ray, interior	22 4	0.381	{ Probably second order of A
	Ray, exterior	22 6	0.385	
	Ray, feeble.....	27 0	0.458	{ Probably second order of B

The above results for copper and iron are in good agreement with those of Moseley [Abstract No. 467 (1914)]. An antikathode of crystalline copper gave precisely the same spectrum as that of the ordinary pure specimen whose spectrum is given in the above table. In the spectrum of gold, the rays C and D are those of copper; the antikathode in this case consisted of a gold plate mounted on a copper block, and during the exposure the gold had been fused, thus exposing the copper to the rays. The iron employed contained nickel as an impurity. The spectra were obtained by reflection from a cubic face of a rock-salt crystal. [*Erratum*, *ibid.* p. 907, March 23, 1914.]

E. A. O.

HEAT.

1081. *Expansion of Mercury and Silica.* **F. J. Harlow.** (Phys. Soc., Proc. 26. pp. 85-94; Discussion, 94-96, Feb., 1914.)—A cylindrical, and also a spherical, bulb of fused silica was fitted with mercury and used as a weight thermometer over the range 0° to 800° C. The results for the two shapes did not differ by more than 1 in 18,000, so that at least as regards these fused silica vessels the longitudinal and radial coefficients of expansion may be considered identical. The bath liquid was paraffin for low, and thick oil for high temperatures. The results for the apparent expansion of mercury in silica are given in a table. Next, Callendar's values for the expansion of silica are used to deduce from the above the absolute expansion of mercury. These results for the range 0° to 100° agree to 10 in 18,000 with those found by Chappuis; whereas they disagree by as much as 70 in 18,000 (for some parts of the range) with those found by Callendar and Moss by the absolute method. In the discussion, **F. E. Smith** considered that the films adhering to glass and silica might cause the great discrepancy mentioned above. If so, all weight-thermometer methods would be suspect. **J. E. Sears** mentioned an empirical equation which Donaldson had obtained to fit the experimental result for mercury. He now produced a quartic which was calculated on the mean best results for silica applied to Harlow's results for the apparent coefficient of mercury. **P. E. S.**

1082. *Thermal and Electrical Conductivity of Copper between 20° and 878° absolute.* **W. Meissner.** (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 262-272, March 15, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The law of Wiedemann-Franz and Lorenz that for all pure metals $\lambda/\kappa T$ is an absolute constant (λ = thermal and κ = electric conductivity, T = abs. temp.) was well established between 0° and 100° C. by the experiments of Jaeger and Diesselhorst although small divergences appeared with the different metals, and a simple theoretical explanation was given on the Drude electron theory of electrical and thermal conduction. Nerust's work on the specific heats of metals at low temperatures has shown this law to be quite untenable in its original form. While Jaeger and Diesselhorst's experiments indicated that λ was almost independent of the temperature, Lees has shown that at temperatures between 18° and -170° C., λ increased in the case of some metals up to 20%. In order to obtain data on the temperature dependence of λ , and on the validity or not of Lorenz's law, experiments were undertaken with the same piece of metal down to the temperature of liquid hydrogen. The electric heating method of Kohlrausch as modified by Diesselhorst was employed, whereby the ratio of λ to κ is directly obtained as also the value of κ . Experimental details illustrated by diagrams are given. The measurements between 0° and 100° C. were made in baths of ice, petroleum, and paraffin oil, while those at lower temperatures were carried out with liquid oxygen and hydrogen. A graphical presentation of the results is given. The value of $\lambda/\kappa T$ was found to be in agreement with Lorenz's law and the experiments of Jaeger and Diesselhorst between 0° and 100° , i.e. a constant, but it slowly decreases with falling temperature and more rapidly at very low temperatures until at 20° abs. it has only a seventh part of

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the value at 0°C . A similar behaviour is seen with the thermal resistance $1/\lambda$, which is practically constant between 0° and 100°C ., but rapidly diminishes at very low temperatures, possessing at 20° abs. only a fourth the value which it has at 0°C . The general conclusion drawn is that neither Lorenz's law nor the assumption of a constant thermal conductivity of metals have any universal validity at low temperatures.

H. H. Ho.

1083. Variation with Temperature of the Specific Heat of Sodium in the Solid and the Liquid State; also a Determination of its Latent Heat of Fusion. E. Griffiths. (Roy. Soc., Proc. Ser. A. 89. pp. 561-574, March 2, 1914.)—Using the method described previously [see Abstract No. 1841 (1918)], the author has determined the specific heat of sodium in the solid and liquid state. The range of temperature in each determination was approximately 1.5° , which made it possible to determine the specific heat close to the melting-point; in fact, determinations were made with the middle point of the range only 2° below the melting-point. The sodium was enclosed in a sheath of copper of special form.

The specific heat values in the solid state depend on the nature of the previous heat-treatment of the sodium; definite, reproducible values could only be obtained when the metal was annealed by slow cooling from the liquid state. Between 0° and 95.53° the specific heat of the solid increases from 0.2829 to 0.8258, the temperature coefficient varying continuously, whilst between 100.81° and 188.47° the specific heat of the liquid decreases fairly regularly from 0.8284 to 0.8189. The freezing-point of sodium, as determined by the cooling curve method, was found to be 97.81° . From time-temperature observations in the solid and liquid states, during the supply of heat at a constant rate, the latent heat of fusion of sodium was found to be 27.52 gm.-cals. Sodium in the quenched state is less dense than in the annealed state, the difference being of the order of 1 part in 7000. T. S. P.

1084. Investigations of Specific Heats at Low Temperatures. VIII. W. Nernst and F. Schwes. (Preuss. Akad. Wiss. Berlin, Ber. 10. pp. 855-870, 1914.)—The authors have further developed the method for the determination of specific heats at low temperatures with the vacuum calorimeter [see Abstract No. 1702 (1911)], and give full particulars of the various improvements. Details of the results obtained, at temperatures varying between 19.1° abs. and 96.5° abs., for the following substances are given: Al, Ti, carborundum, calcium oxide, calcium hydroxide, calcspar, silver chloride, silver iodide, potassium aluminium sulphate, Mg, Si, lead oxide, and lead iodide. The T^3 -law of Debye holds at these low temperatures for Al, carborundum, and Si.

T. S. P.

1085. Transition Temperatures of the Hydrates of Sodium Carbonate as Fixed Points in Thermometry. T. W. Richards and A. H. Fiske. (Amer. Chem. Soc., Journ. 86. pp. 485-490, March, 1914.)—In continuation of previous work [see Abstract No. 1178 (1911)] the authors have determined the transition-point of sodium carbonate decahydrate to the heptahydrate, and found it to be 82.017° on the hydrogen scale (82.121° on the mercury thermometer). The other hydrates have also been analysed, and the statements of other investigators confirmed. It is shown, however, that all the hydrates lose water easily at ordinary temperatures into air dried by concentrated sulphuric acid, leaving the salt essentially anhydrous.

A. F.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1086. *Electron Theory of Metallic Conduction*. W. F. G. Swann. (Phil. Mag. 27. pp. 441-454, March, 1914.)—Drude obtains the relation $\sigma = ne^2\lambda v/4a\theta$, where σ is the electric conductivity, n the number of electrons per c.cm., λ the mean free path, and $a\theta$ is the kinetic energy of a gas molecule at a temperature θ . It is obtained on the assumptions that in the absence of an electric field all the electrons move with the same velocity, and that the velocity arising from a field is the velocity produced while travelling between two points of collision, the essential assumption being that at each collision the effect of all previous actions of the field on the electron are wiped out. The author shows that Drude's calculation is vitiated by some purely mathematical errors, and that the correction of these leads to the formula $\sigma = ne^2\lambda v/8a\theta$. Drude's formula, however, and not the correct deduction from his assumptions, is in agreement with experiment. Now the only practicable combination of the physical qualities involved which is of the dimensions of electric conductivity is that of these formulæ, so that the numerical factor is the only part which depends on the correctness of the theory on which it is founded. The conclusion is therefore that the assumptions are nothing like as representative of the facts, as has been supposed, even in the matter of the relation between the thermal and electrical conductivity, a question to which a special investigation is devoted. Riecke, in 1898, before the publication of Drude's result, had obtained a formula which, when interpreted in terms of the modern electron theory, agrees with that here obtained from the same assumptions [see Abstracts Nos. 299, 1024 (1899)]. Drude's error has also been pointed out recently by Bohr.

G. W. DE T.

1087. *Mean Energy of a Rotating Electric Molecule in a Radiation Field*. A. D. Fokker. (Ann. d. Physik, 48. 5. pp. 810-820, March 18, 1914.)—Eucken [see Abstract No. 517 (1912)] observed that for hydrogen the curve for specific heat approaches the specific heat axis asymptotically at the absolute zero. Attempts to explain these results of Eucken's have already been made by Einstein and Stern and by Ehrenfest [see Abstracts Nos. 1016, 1445 (1918)]. A molecular agitation at the absolute zero was assumed by the former, but not by the latter. In the present paper an attempt is made on different lines to explain the hydrogen results. This is based on Einstein's theory of the specific heat of rigid bodies. In that theory a rigid body is subjected to oscillations of definite frequency in consequence of its elasticity: heat energy is considered to be the energy of these oscillations. If the oscillating systems are supposed to be charged the heat capacity is unaltered, but these oscillators can then be considered to be in energy equilibrium with black radiation, and hence each has the mean energy of a Planck resonator of the same frequency. Hence assuming Planck's radiation formula to be correct, the amount of energy in each oscillating system is known, and thus also the specific heat. This method is applied to hydrogen, where the oscillating systems are taken to be the molecules, which are considered charged. It leads to the result that the specific heat curve would have a tangent which is vertical at the absolute zero, whilst Eucken's results showed a horizontal tangent.

J. R.

1088. *The Electromagnetic Field of Force.* T. Gross. (Zeitschr. Vereines Deutsch. Ing. 57. pp. 1952-1954, Dec. 6, 1918.)—An abstract of a series of researches by the late T. Gross, to be published by the Verein Deutscher Ingenieure. They constitute a revision of magnetic theory. Among the conclusions reached are the following. The magnetic field of a steady current has magnetic forces only along its lines of force, not between these; any forces between these are not magnetic. The repulsion between a diamagnet and a magnet depends on the diamagnet, and is independent of the polarity of the magnet; it cannot depend on the magnet. Diamagnetism therefore differs in its nature from magnetism. The action between a magnet and a diamagnet is at right angles to the axis of the former and to its lines of force. Bodies tend so to place themselves in a magnetic field that their magnetic resistance shall be a minimum. Diamagnetic fields have to be recognised as well as magnetic. In a diamagnetic field an iron bar places itself equatorially, like a bar of bismuth in a magnetic field. Bismuth places itself axially in a diamagnetic field, like iron in a magnetic field. The diamagnetic field repels iron, attracts bismuth. Cu, Ag, Au act as magnets in a magnetic, as diamagnets in a diamagnetic field; such substances are "amphibolous." These substances present peculiar phenomena when in the form of a ring. In very weak fields they act as weakly magnetisable substances. In the form of spheres they are attracted in a magnetic, repelled in a diamagnetic field. There is a diamagnetic induction as well as a magnetic induction by a steady current. By diamagnetic self-induction currents can be induced on magnets. The induced diamagnetic lines lie in the same plane as the induced current and the axis of the magnet. In the field of an alternating current amphibolous bodies and closed induced current coils of small size rotate continuously so as to bring points opposed on the axis of the field to lie equatorially; but they do not rotate if symmetrical with regard to the axis or the equator. Bodies distinctly paramagnetic or diamagnetic do not rotate. In an electromagnetic field we have to distinguish between magnetic forces, diamagnetic forces, and induction. The first two of these are ponderomotive; the last acts only as a resistance. The repulsion of a secondary coil is a diamagnetic phenomenon, the secondary coil being an electrodiamagnet. We have to distinguish between electromagnetic or electrodiamagnetic phenomena in a field of force and electrodynamic phenomena between two fields of force, independent of one another. With alternating inducing currents, on the other hand, there is no continuing electrodynamic action unless the two have a common magnetic field. The alternating current can induce magnetisation, but the magnet pole induced attracts either pole of an ordinary electromagnet or magnet. Ponderomotive electrodynamic forces exist always between steady currents, never between steady and alternating, and between two alternatings only when one of these is induced in the field of force of the other. An alternating and a steady current along the same wire act electrodynamicly with regard to a third as two independent currents. Two currents, i_1 , i_2 , along the same wire, acting electrodynamicly upon one another; the energy of either, for unit resistance, is $i^2 + i_1i_2$ or $i_2 + i_1i_2$, the energy of either alone plus the electrodynamic energy between them. If they do not act electrodynamicly on each other, the energy of either is i_1^2 or i_2^2 simply, as if i_1 or i_2 had been alone.

Rotatory apparatus of a new kind is described; a coil bearing an alternating current, placed with its axis at right angles to a steady magnetic field, rotates; so does a coil carrying a steady current similarly placed in an alternating magnetic field. The steady current is a progressive, the alter-

nating current a stationary wave, whose components are the electric, the magnetic, and the diamagnetic oscillation ; of which the last is called the "current." The fundamental law is that similarly vibrating, similarly directioned oscillations repel one another ; those vibrating in opposite directions attract one another. Paramagnetic bodies absorb the magnetic lines of force more powerfully than air does, and become magnetic ; non-conductors absorb the electric lines more powerfully than air does, and become electrically charged. Currents were obtained in open circuits. By means of an alternating current permanent magnets were obtained which had no opposed poles, but whose attraction and repulsion of a suspended magnet-needle depended much more upon the relation of their axis to the plane of oscillation of the magnet-needle. A. D.

1089. *Accelerated Conductors.* R. C. Tolman, E. W. Osgerby, and T. D. Stewart. (Amer. Chem. Soc., Journ. 86. pp. 486-485, March, 1914.)—The force of gravity has been found to produce a difference in electrical potential between the two ends of a vertical tube of salt solution. This difference in potential evidently arises from the unequal weights of the positive and negative carriers of electricity in the solution. Thus the lower end of a tube of potassium iodide solution becomes negatively charged, since the negative iodide ions are heavier than the positive potassium ions. In a similar way we should expect a tube of solution, when subjected to acceleration, to show a difference in potential between the two ends. For example, the rear end of a tube of potassium iodide solution should show a negative charge so long as the tube is being accelerated.

The apparatus used by the authors for accelerating electrolytes consisted essentially of a glass tube provided with electrodes and bent to fit the rim of an ordinary bicycle wheel. The tube was filled with electrolyte, the wheel given a sudden acceleration, and the current noted which flowed through a galvanometer placed in the external circuit. Sodium iodide and lithium iodide solutions were tried, and the observations gave conclusive proof that potential differences are developed at the ends of a column of accelerated electrolyte. Experiments were also tried with metallic conductors, and showed that the mass of the carriers in metals is probably less than one two-hundredth of that of the hydrogen atom. E. H. B.

1090. *Nuclear Electrons.* A. van den Broek. (Phil. Mag. 27. pp. 455-457, March, 1914.)—Shows that Rutherford's theory and the experimental data both agree in giving for the intra-atomic charge, not half the atomic weight, but the number M which each element occupies in Mendelejeff's series arranged in order of increasing atomic weight. E. H. B.

1091. *Quantum Theory and Rational Units.* G. N. Lewis and E. Q. Adams. (Phys. Rev. 8. Ser. 2. pp. 92-102, Feb., 1914.)—A discussion of the numerical relations between the electron charge, the Wirkungs-quantum, and the constant of Stefan's law. An endeavour is also made to found a rational system of units. E. H. B.

1092. *Some Questions Relative to the Lorentz Transformation in Electrodynamics.* R. Marcolongo. (Accad. Lincei, Atti, 22. pp. 402-408, Nov. 9, 1918.)

1093. *The Problem of Two Spherical Conductors.* G. R. Dean. (Phys. Rev. 1. Ser. 2. pp. 816-820, April, 1918.)—Mathematical.

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1094. Fall of Electrical Potential in the Free Air up to 9000 m. E. Everling. (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 240-244, March 15, 1914.)—Previous investigators have shown by means of observations made from a free balloon, that the fall of potential diminishes with increasing height from about 100 volts/m. at ground-level to about 25 volts/m. at 1500 m.; about 10 volts/m. at 4000 m.; and about 8 volts/m. at 6000 m. height. Measurements from a free balloon are given according to which the rate of fall diminishes with increasing height in a logarithmic manner. There is some doubt about the absolute values of the gradient at different heights, with reference to which further experiments are in progress, but from a comparison with previous ascents made in similar anticyclonic weather, it appears that the gradient at 9000 m. is about 8.5 volts/m. R. C.

1095. Atmospheric Electric Potential Results at Edinburgh during 1912. G. A. Carse and G. Shearer. (Roy. Soc. Edinburgh, Proc. 88. pp. 817-882, 1912-13.)—The results of some previous intermittent observations on atmospheric electricity have already been brought forward in an earlier paper [see Abstract No. 1804 (1910)]. The present series was nearly continuous during 1912, and refers to potential gradient only. Autographic records were obtained from a water-dropper of the well-known Kelvin type to which was attached an apparatus which earthed the water tank for 5 minutes at the end of every hour. This provided a series of time marks and also indicated the zero line. Absolute observations were made with a Wilson universal electrometer which measures the charge induced by the earth's field on a horizontal plate. A flame collector was also sometimes used. Frequent eye readings on one or two days gave curves in very close agreement with the autographic records, but the latter showed a slightly greater lag, as would be expected from the greater electrical capacity of the instrument. For hourly values the curves were tabulated by measuring the area cut off between consecutive hour marks and so deducing the mean potential for the hour. The annual range shows a well-marked maximum in Jan. and a minimum during the summer. This is in agreement with the type of annual variation found at other stations. Mean daily curves are given for each month and for the summer and winter halves of the year. An early morning minimum at about 4 a.m. is noticeable on all the curves. Harmonic analysis of the daily variation shows that the amplitude (a_1) of the 24-hour term is greater than that of the 12-hour term (a_2) during the winter months and less in the summer. The value of a_1 varies from 8 volts/m. in Sept. to 71 in Jan. The variations in the phase of the 24-hour term follow the time of sunrise. The mean gradient at Edinburgh throughout the year was 187 volts/m., somewhat greater than the average for continental stations. J. S. Dr.

1096. Measurements of Electrical Conductivity in the Free Air up to a Height of 9000 m. A. Wigand. (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 282-289, March 15, 1914.)—The method of observing is to carry a Gerdien apparatus [see Abstract No. 2078 (1905)] or a modification of it on a manned balloon and to make observations of λ_+ and λ_- at frequent intervals. The results of four separate ascents are given, the max. heights attained in which were respectively 5400 m., 6800 m., 8510 m., and 9005 m. The total conductivity λ ($=\lambda_+ + \lambda_-$), for each ascent increases with increasing height at an increasing rate.

At the surface λ is of the order of 10^{-4} e.s. unit; at 1000 m. it varies from 10^{-4} to 4×10^{-4} for the different ascents; at 5000 m. it varies from 11×10^{-4} to VOL. XVII.—A.—1914.

17×10^{-4} , while the values at 7000, 8000, and 8880 m. for the single ascent for which the results are plotted are 18×10^{-4} , 25×10^{-4} , and 87×10^{-4} e.s. unit.

The explanation of the increase is ascribed partly to the diminished pressure of the air which induces an increased mobility of the ions, and partly to an increase in the number of ions aloft. The shape of the curve for change of intensity of ultra-violet radiation with height is similar to that for electrical conductivity.

R. C.

1097. *Note on a Theory of Thunderstorms.* H. Nagaoka. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 228-281, Feb., 1914.)—It is considered that the phenomenon of repeated discharges can be accounted for from the standpoint that the thunderclouds form a composite dielectric. The dielectric contains clouds, ions, and air, and the charges are embedded in it. The charges accumulate, the electric field increases in strength, and the wandering of the ions and distribution of cloud particles become favourable for causing a discharge through the intervening layer. Such a composite dielectric will exhibit electric absorption and residual discharge. Further, the disruptive discharge is the cause of fresh production of ions. The sudden change of pressure in the path of the discharge will sometimes be quite favourable to the condensation of water particles on electrified nuclei. The phenomenon of repeated discharges is, on this account, a natural consequence of electric absorption in cloud masses. [See Abstract No. 1078 1909.]

G. E. A.

DISCHARGE AND OSCILLATIONS.

1098. *Recombination of Gaseous Ions.* G. Rümelin. (Ann. d. Physik, 48. 6. pp. 821-857, March 20, 1914.)—A method of measuring the rate of recombination of gaseous ions is described which has the following advantages: Small quantities of gas only are needed since the gas remains at rest; the recombination is allowed to go on freely in the gas without disturbance by an electric field; and, further, the rate of recombination is determined at various small intervals after the production of the ions which, however, goes on continuously. The procedure is as follows. Dry dust-free gas contained in an enclosed cylindrical condenser is ionised continuously by the α - or β - + γ -rays of either Ra or Ur. Recombination is allowed to go on undisturbed for a short time, at the end of which the ions are swept out by a strong field applied for another short period. This procedure is repeated continuously by means of rotating contacts, the resulting ionisation current being measured by means of a suitable electrometer. By altering the speed of the rotating contacts the length of time during which the recombination goes on, and therefore the ionisation current, can be varied. The curve obtained by plotting the ratio of the ionisation current to the saturation current against the speed of the rotating contacts departs somewhat, especially in the case of ionisation by α -rays, from that obtained from theory on the assumption that the rate of recombination is constant. The direction of the departure is such as to indicate that recombination takes place at a greater rate immediately after the ions are produced than subsequently. This observation agrees with the view given by Bragg and others that there exists a greater tendency for two ions just formed from a molecule to recombine to form that molecule than exists between the ions at random subsequently. By taking this "initial recombination" into con-

sideration a theoretical curve is obtained which agrees much more closely with the experimental curve, particularly for the slower speeds of rotation of the contacts. Views other than Bragg's which would account for the departure of the experimental curve from the theoretical are also discussed. The effect of the alteration of gas pressure upon the coefficient of recombination is also investigated. The coefficient decreases with decrease of pressure; the observations of Langevin and others are thus qualitatively confirmed.

F. J. H.

1099. *Discharge in a Magnetic Field.* R. F. Earhart. (Phys. Rev. 8. Ser. 2. pp. 108-114, Feb., 1914.)—After giving a brief review of previous work in this direction, the author proceeds to describe experiments made with a view to obtaining quantitative measurements of the effect of a uniform longitudinal magnetic field upon a luminous discharge taking place between the central portions of a parallel plate condenser. With such an arrangement the conditions are somewhat simplified. A series of characteristic curves are given for air, H, and CO₂ at various pressures above and below the critical, and for various values of the magnetic field ranging from 0 to 10,000 c.g.s. units. The results indicate that at pressures below the critical pressure a weak field increases the current obtained for a given p.d., while a strong field reduces it. The lower the gas pressure the greater must be the critical value of the magnetic field to secure a reduction of current. At pressures close to the critical the effects of magnetisation are small, but above the critical pressure the longitudinal field reduces the current. The results of the paper are considered in their relation to the explanations of Strutt's experiment given by Townsend and Horton [Abstracts Nos. 582 and 588 (1914)].

F. J. H.

1100. *Long-wave Limits of the Normal Photoelectric Effect.* A. L. Hughes. (Phil. Mag. 27. pp. 478-475, March, 1914.)—Pohl and Pringsheim recently discussed the present position of certain questions in photo-electricity and concluded that there was not sufficient evidence to determine the relation between the max. emission velocity of photo-electrons and the frequency of light [see Abstract No. 719 (1914)]. Two laws have been proposed for the relation between the velocity and the frequency, the first being that the velocity squared, or the energy, of the photo-electron is proportional to the frequency; the second is that the velocity is directly proportional to the frequency. On account of the small ranges of wave-lengths available it is difficult to decide which is the correct relation, but it is suggested that the investigations of Richardson and Compton, as well as those of the author undoubtedly show that the results are well expressed by the first law but not by the second. Pohl and Pringsheim, in support of their contention, refer to the experiments by Kunz and Cornelius, who conclude that their results are better expressed by the second law. The experimental arrangements of Kunz and Cornelius are open to considerable objections, and it appears that, notwithstanding the objections raised by Pohl and Pringsheim, which are briefly discussed, the balance of opinion is in favour of the first law.

A. E. G.

1101. *Kathode Disintegration in a Vacuum Tube.* A. M. Tyndall and H. G. Hughes. (Phil. Mag. 27. pp. 415-427, March, 1914.)—In the present experiments the following factors are dealt with:—The duration of the discharge; the previous history of the kathode; the pressure and nature of the gas; the current density; and the kathode-fall of potential. The amount of

disintegration is measured in all cases by the loss of weight of the kathode. During discharge it is found necessary in general to control and measure pressure, current, and kathode-fall. A diagram of the experimental arrangements is given. As the result of these experiments the following general conclusions are arrived at. Provided that a constant kathode-fall is maintained: (a) Considerable changes of pressure have no influence on the amount of disintegration for a given current and duration of discharge; (b) new and old kathodes of the same area disintegrate practically to the same extent under the same conditions of current and duration of discharge; (c) the rate of disintegration for a given current density is constant throughout discharge. Thus it is not affected by the removal of gases from the surface of the kathode by previous discharges. The influence of the kathode fall of potential on the rate of disintegration has been investigated at low values of kathode-fall. No simple relationship (such as exists at high values) has been observed. The rate of disintegration appears to vanish at the normal kathode-fall. The linear relationship which exists between current densities and high kathode-falls does not hold in the general case. Preliminary work on the influence of the nature of the gas shows that at low values of kathode-fall there is no appreciable difference between rates of disintegration in hydrogen and air under similar conditions. Certain theoretical considerations are advanced in connection with some of the above results.

A. E. G.

1102. *Attempts to Observe the Production of Neon or Helium by Electric Discharge.* R. J. Strutt. (Roy. Soc., Proc. Ser. A. 89, pp. 499-506, Feb. 2, 1914.)—An endeavour was made to repeat the experiments of Collie and Patterson, the method used being one in which hydrogen could be removed and the test for neon carried out without pumping the gas out of the apparatus or manipulating it over a pneumatic trough in any way. It is extremely difficult to avoid in the latter processes the entrance of minute air-bubbles entangled between mercury and glass. In the experiments the neon contained in 1/100 c.cm. or even 1/1000 c.cm. of air could be detected. The results obtained were negative, and no trace of Ne or He could be obtained by spectroscopic observations.

J. J. S.

1103. *Discharge from Liquid Points, and a Method of Measuring the Electric Intensity at their Surfaces.* J. Zeleny. (Phys. Rev. 8, Ser. 2, pp. 69-91, Feb., 1914.)—Hitherto the discharge from pointed conductors has been studied only from points made of metal. The assumption is generally made that the phenomena of the discharge are independent of the metal of which the point is made, yet there are some facts which show that some importance attaches to surface conditions. Hence it is advisable to extend the study to materials which differ radically from metals. The author describes a method for examining the discharge from a small liquid hemispherical drop, protruding from a capillary tube, on to a plane electrode below it. The same apparatus serves for determining the surface tension of the liquid from measurements of the drop, and also for measuring the electric intensity at the surface of the point. This intensity is determined as follows. When the drop is charged the electric force acting at the surface tends to pull it outwards. The meniscus may be made to return to its position before charging by decreasing the hydrostatic pressure inside the drop. The decrease in hydrostatic pressure is equal to the electrostatic pressure due to charging, hence by measuring the former the electric intensity at the

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surface may be found. The liquid used in the work described is water slightly acidulated, and the radii of the drops vary from $r=0.0146$ to 0.0548 cm. It is found that the positive discharge from the point begins with a momentary current, repeated only by increasing the potential of the point. At higher potentials the current is intermittent, the luminosity of the discharge starts from a small area on the surface, and extends half-way to the plane electrode, and the meniscus is agitated. At still higher potentials the current is steady, luminosity covers the whole surface, and is confined to it, while the liquid meniscus is quiescent. The negative discharge is always in the form of a brush discharge, current almost always intermittent, and meniscus in motion, while the luminosity starts from a small area and extends out a distance of the order of the diameter of the point. The relation $f\sqrt{r}=\text{constant}$ is found, where f is electric intensity at the discharging surface when the current just ceases to flow, and r is the radius at the point. The electric forces under these conditions as well as the potentials at which the currents cease, are the same for both negative and positive discharges. These intensities are considerably smaller than those obtained by Chattock with Pt-points, and somewhat smaller than those calculated by the author, from measurements on brass points [see Abstracts Nos. 118 (1908) and 1481 (1910)]. For small points the electric intensity does not vary much with the current, for larger points the values increase to a maximum as the current is increased.

The action of β - and γ -rays is to lower the starting potential of the discharge slightly. Discussion of the results is postponed until a later paper.

T. H.

1104. *On the Question of the Oscillatory Discharge of a Condenser.* V. Smirnoff and A. Fridmann. (Russian Physico-Chemical Soc., Journ. 45. pp. 276-282 [Physical Part], 1918. In Russian.)—Designating by V the difference of potential, and C , L , and R possessing their usual significations, the following equation holds:—

$$\frac{d^2V}{dt^2} + \frac{R}{L} \frac{dV}{dt} + \frac{1}{LC} V = 0.$$

The author quotes from the work of Fuchs, N. A. Boulgakov, and D. A. Roschansky. An expression is found for V_1 which is shown to be dependent in part upon α , β , and γ , where

$$\alpha = -\frac{r}{aL}, \quad \beta = -\frac{R}{aL}, \quad \gamma = \frac{1}{LCa}, \quad \text{E. O. W.}$$

1105. *Production of Electric Oscillations by the Arc.* J. Zenneck. (Ann. d. Physik, 48. 4. pp. 481-524, Feb. 27, 1914.)—The period during which the oscillations generated by the arc method are rising to their full amplitude is investigated theoretically and experimentally. The ordinary experimental arrangement is employed. In the developing of the theory the change in the amplitude from period to period only is considered, and this brings the energy equation of the oscillation circuit into a form which admits of easy integration, even for very complicated characteristics. The effects produced when the static characteristic holds are first investigated theoretically, and this leads to the Duddell conditions for oscillations. The change in the phenomena due to the dynamic characteristic is then considered, and Braun-tube photograms of the dynamic characteristics are given and explained. Photograms of the corresponding static characteristics are also

given. Braun-tube oscillograms of the rise of the oscillations are then given showing how the theoretical considerations are borne out. It is pointed out that after the oscillations of the second kind are established the resistance of the condenser circuit may be raised considerably above the critical value of this resistance for the initial conditions without destroying the oscillations.

T. P. B.

1106. *Vibrations of Lecher System with Lecher Oscillator*. III. F. C. Blake and C. Sheard. (Phys. Rev. 8. Ser. 2. pp. 217-281, March, 1914.—Paper read before the Amer. Physical Soc., Dec., 1912, and before the Ohio Acad. of Sci., Oberlin, Nov., 1918.)—It was previously found that when the Lecher system was in exact tune with the oscillator and receiver circuits, Abraham's theory ought to apply, provided the harmonics were damped out proportionally. The authors then proposed to test this point, and in this paper give some of the results obtained by working in this direction. They conclude that three conditions need to be fulfilled if the various tones are to be strictly harmonic, viz., (1) the distance between the Lecher wires must approach zero; (2) the end capacity must approach zero; and (3) the coupling must be loose at both ends of the Lecher system. [See Abstract No. 1572 (1912).]

E. H. B.

1107. *Calculation of the Free Period of a Single-layer Coil*. W. Lenz. (Ann. d. Physik, 48. 5. pp. 749-797, March 18, 1914.)—Drude, in a paper on the Tesla transformer [see Abstract 1906 (1902)], calculated the free period of a coil and measured it experimentally in a number of cases. His experimental results showed that the fundamental wave-length is of the same order of magnitude as the total length of wire used, and that it depends only slightly on the distance apart of the separate windings. His theoretical treatment was only a rough approximation, as he considered the capacity concentrated at the ends of the coil. In the present paper the capacity is considered to be distributed throughout the whole length of the coil, and a much more probable approach to facts is thus obtained. The problem is difficult, but it is shown that the coil may be considered as a cylinder with the turns fused together. The paper is divided into three parts: (1) a discussion of short coils for which the length is small compared with the radius; (2) a discussion of long coils; and (3) a comparison of theory with experiment. The general results are that for short coils the wave-length of the fundamental oscillation is large compared with the total length of wire, and *vice versa* for long coils. The overtones differ much from the harmonic series. For short coils the overtones lie farther apart than the harmonics, and for long coils nearer together. The formulae given for the fundamental and overtones of a long coil are very complicated, but for a short coil the wave-lengths of the fundamental and first overtone are

$$\lambda_1 = \sqrt{\frac{\epsilon_i + \epsilon_e}{2}} \cdot \frac{\pi}{2} \cdot L \cdot \sqrt{2 \log \frac{16R}{l} - 7}; \quad \lambda_2 = 0.882 \cdot \frac{\pi}{2} \cdot L \cdot \sqrt{\frac{\epsilon_i + \epsilon_e}{2}},$$

where $2l$ is the length of the coil, L the total length of wire, R is the radius of the coil, and ϵ_i and ϵ_e are the specific inductive capacities of the core and exterior of the coil. These expressions are simplified if $\epsilon_i = \epsilon_e = 1$, the value for air.

In addition to Drude's experimental results, some measurements were made by R. Lindemann to test the theory. There are discrepancies of from

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10 to 20 % between calculated and observed wave-lengths, the least disagreement being for short coils ($l/R < 1$) where the windings are far apart. A very close agreement is found when the ratios of the wave-length of the first overtone and the fundamental are plotted against R/l . J. R.

1108. *Phenomena in Oscillation Circuits. II.* F. F. Martens. (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 220-227, March 15, 1914.)—This second article of the series deals with the instantaneous values of the variables in two coupled circuits with small damping and medium coupling. [See Abstracts Nos. 668 (1918) and 782 (1914).] E. H. B.

1109. *Some Instruments for High-frequency Currents and Voltages.* W. H. Eccles. (Electrician, 72. pp. 1044-1045, March 27, 1914.)—A description of a simple hot-wire ammeter of quick period, a very sensitive electrometer of simple construction and a convection galvanometer. All have been employed successfully by the author for high-frequency work. T. P. B.

1110. *The Propagation of Electromagnetic Waves in Wireless Telegraphy.* G. R. Dean. (Electrician, 78. pp. 18-17, April 10, 1914.)—A mathematical treatment of the simple Hertz element and the electric doublet. L. H. W.

1111. *Electric Emissivity of Matter.* J. A. Harker. (Engineering, 97. pp. 290-291, Feb. 27, 1914. Lectures delivered at the Royal Inst.)—[See Abstract No. 1718 (1918).]

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1112. *Properties of Selenium.* G. W. White. (Phil. Mag. 29. pp. 870-882, Feb., 1914.)—When a selenium block is illuminated the resistance-change in the direction of the light is appreciable even with thick blocks. This fact was utilised to prepare a Se block, the conductivity of which could be measured (a) in a direction parallel to the illuminated face ("bridge" of the first type), and (b) in a direction perpendicular to this face ("bridge" of second type). The resistance-change on illuminating a Se block is always greater when used in a bridge of the second type. The change in conductivity throughout a thin layer at the illuminated surface of a homogeneous block is insufficient to explain this phenomenon. The effect of light on Se blocks, the effect of filing the surfaces, and the dependence of the resistance on the nature and pressure of the electrodes, on the voltage and on certain other conditions, all point to the existence of a high resistance at the contact of the selenium and the electrodes. The action of light on all selenium bridges is to a large extent, but not wholly, to effect a change of resistance at the electrode contact. Films of Se can be obtained by "kathode disintegration." If the deposit is received on a plate at a suitable temperature the films are continuous and light-sensitive. J. J. S.

1113. *Physical Properties of Selenium.* P. J. Nicholson. (Phys. Rev. 8. Ser. 2. pp. 1-24, Jan., 1914. Phys. Zeitschr. 14. pp. 1210-1218, Dec. 1, 1918. Abstract.)—Experiments were undertaken with the object of obtaining data that would help in solving the problem of the cause of the behaviour of selenium when exposed to light, and first the production of good films of Se in various forms was attempted. Considerable information was collected regarding the sputtering of Se kathodes, and an improved form of sputtering

apparatus was made use of. Many semi-transparent films of amorphous Se were transformed into the metallic state. The ultra-violet absorption of metallic Se was roughly determined. Selenium cells have been found to retain a large sensibility down to $280\ \mu\mu$, and the sensibility curve for short wave-lengths was determined. Sensibility curves were obtained when exposure was limited and of varied duration as well as when a steady state was reached. The law $d = DI^\beta$ was found to hold with considerable accuracy, where d = change in conductivity, I = energy of incident beam, and β and D are constants. When exposure is between 12.5 secs. and 20 secs. Pfund's results are confirmed that $\beta = 1$ in red and infra-red, but $\beta = \frac{1}{2}$ for shorter wave-lengths. For unlimited exposures $\beta = \frac{1}{2}$ throughout the spectrum. The law $d = DI^\beta$ was found to hold with considerable accuracy when the exciting source was Röntgen rays; β being 1 for short exposures and $\frac{1}{2}$ when time of exposure is unlimited. A mathematical deduction has been made, with the electron theory as a basis, from which the most important facts known regarding the behaviour of Se cells follow, e.g. :— (1) Variation of change in conductivity with square root of intensity for long exposures. (2) Variation of change in conductivity directly with the intensity when time of illumination is short compared with that required to reach a steady state. (3) High sensibility of cells of high resistance. (4) Decrease of inertia with increasing intensity of illumination, absorption coefficient, and "dark conductivity." This also explains variation of sensibility with temperature and other disturbing factors. (5) Dependence of rate of recovery upon the same causes. (6) Change in sensibility when cell is illuminated continuously with a beam of light for whose constituents k , the coefficient of absorption, is nearly constant. (7) Decrease in inertia when this beam is red, or infra-red. (8) Possible explanation of "light-negative" selenium and anomalous effects.

J. J. S.

1114. *Base Metal Thermo-couples*. O. L. Kowalke. (Amer. Electrochem. Soc., Trans. 24. pp. 877-889, 1918.)—Investigations were made on various thermo-couples which have recently come into use for industrial purposes and are made of metals such as iron and nickel and alloys of nickel, cobalt, etc. The object was to determine how the e.m.f. of the couples varied with the temperature and how its constancy was affected by successive heatings and coolings, and by exposure to various temperatures for extended periods of time. The couples tested were all compared with a Pt and Pt-Rh couple which had been standardised by means of a similar couple certified by the Bureau of Standards. It seems from the experiments made that it is possible to obtain a base-metal couple which is reasonably homogeneous and will give indications of temperature which are sufficiently constant to meet the needs and requirements of the industries. For measurements of a greater accuracy than within 25° a higher grade of instrument is required. Manufacturers are not always sufficiently careful in thoroughly annealing couples to remove strains resulting from mechanical treatment. Once the couple has attained its permanent structure there does not seem to be much change in the e.m.f.

J. J. S.

1115. *Thermoelectric Behaviour of Metals at Low Temperatures*. G. Weitzel. (Ann. d. Physik, 48. 4. pp. 605-622, Feb. 27, 1914. Abstract of Dissertation.)—The author employed a compensation method of measurement and obtained, even at low temperatures, a constancy within less than a hundredth of a degree. The thermo-e.m.f.'s of pure metals, as well as

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some alloys, were measured with reference to lead in the temperature region between 14° and 278° abs. Some metals were also tested in the annealed condition. From the measurements as well as the curves of the e.m.f. the values of dE/dT were calculated. While various kinds of the same metals may differ in their e.m.f.'s, their E , and especially their dE/dT , curves have usually the same characteristic appearance. Annealing does not usually change significantly the large e.m.f.'s, but with the smaller values its action is proportionately higher, as in the case of pure gold. The curves obtained indicate that with large e.m.f.'s dE/dT has a tendency to decrease. The curves lengthen so freely that for them the relation of Nernst holds, viz. $\lim_{T=0} (dE/dT = 0)$. That with some metals with small e.m.f. the value of dE/dT does not decrease in the observed region, depends probably on the fact, that with such thermo-elements the difference $(dE/dT)_{AB}$ may increase while the members $(dE/dT)_A$ and $(dE/dT)_B$ follow Nernst's relation and with falling temperature will become smaller $[(dE/dT)_{AB} = (dE/dT)_A - (dE/dT)_B]$. At yet lower temperatures the measured $(dE/dT)_{AB}$ will probably first follow the heat law of Nernst, i.e., dE/dT will fall off to $\lim_{T=0} dE/dT = 0$. J. J. S.

1116. *E.M.F. due to Temperature Gradient in a Metal.* H. Hørig. (Ann. d. Physik, 48. 4. pp. 525-554, Feb. 27, 1914.)—The author has applied the method of comparison of capacities, as used by Bijl in the measurement of contact potential, for the determination of the e.m.f. which arises from the unequal heating of different portions of a metal rod or wire. The metals examined were silver and nickel, and it was found that the e.m.f. between warm and cold Ag or Ni in the temperature-range of 20° to 150° C. does not exceed the limits of $\pm 8.5 \times 10^{-6}$ volt per degree of temperature difference. The hot metal was placed in a vacuum of 10^{-5} to 10^{-6} mm. Hg. J. J. S.

1117. *Calibration Tables for Thermo-elements.* L. H. Adams. (Amer. Chem. Soc., Journ. 86. pp. 65-72, Jan., 1914.)—Two tables are given for use with copper-constantan and platinum-platino-rhodium thermo-elements. These will save much trouble in converting microvolts into degrees. In the case of copper-constantan the table was calculated from the equation $E = 74.672t - 18892(1 - e^{-0.000011t})$, where E is the e.m.f. in microvolts, t the temperature (Centigrade) and e the base of natural logarithms. The Pt-Pt-Rh Table was calculated in three sections: the first from an exponential equation of the form $E = At + B(1 - e^c)$; the second from the equation

$$E = -808 + 8.2294t + 0.001649t^2;$$

and the third by inverting the table of Sosman.

J. J. S.

1118. *Thermal Electromotive Forces in Oxides.* C. C. Bidwell. (Phys. Rev. 8. Ser. 2. pp. 204-216, March, 1914.)—Various observations have previously been made by Seebeck and others on the e.m.f.'s across junctions composed of oxides, sulphides, silicates, and other compounds, but attempts have not been made to study prepared specimens of oxides or other compounds of known chemical purity. This paper is a preliminary attempt to plot e.m.f.-temperature relations and to determine the thermoelectric lines for oxides and other compounds. Further details on some points have yet to be obtained. In the experiments pure oxides were fused where possible in the oxy-hydrogen flame or baked into hard rods. The results are given in tables and curves. The thermoelectric diagram obtained shows that the Tait diagram may be extended to include the oxides. Also the thermo-

electric powers for the oxides are of far greater magnitude than for the metals. Values above 1000 microvolts per degree are recorded for some oxides, while for the metals a value of 120 microvolts per degree is extreme. On the diagram for the oxides, as in the Tait diagram for metals, thermoelectric powers are high where resistances are high. The oxides examined include Fe_3O_4 , CuO , V_2O_5 , WO_3 , ZnO , CdO , Cr_2O_3 , Co_2O_3 , SnO , NiO , Bi_2O_3 , Mn_2O_3 , and PbO .

J. J. S.

1119. *Thermal E.M.F. between Metals and Metallic Oxides.* S. L. Brown. (Phys. Rev. 8. Ser. 2. pp. 289-240, March, 1914. Abstract of paper read before the Amer. Physical Soc., Dec., 1918.)—It was found that a considerable e.m.f. is generated when a cold wire is brought in contact with a similar or dissimilar hot wire. These e.m.f.'s are due to the oxides formed on the heated metals and were measured in some cases. For a copper and copper-oxide couple the thermoelectric equation would be fairly accurately expressed by the parabola $E = 0.105t + 0.00175t^2$, where E is in millivolts and t in degrees Centigrade. The results emphasise the necessity of close contact between the metals of any thermo-couple, since a very small difference between the temperatures of the wires would produce erroneous results if an oxide separated the wires. An e.m.f. of half a volt or more can easily be maintained between two copper rods by heating one in a flame to redness and holding the rather sharp point of another large rod in contact with the oxide on the hot rod. [See preceding Abstract.]

J. J. S.

1120. *Validity of the Thermodynamical Relations for the Peltier and Thomson Effects, and Galvano- and Thermo-magnetic Effects for Variable Conductors.* G. Gottstein. (Ann. d. Physik, 48. 7. pp. 1079-1100, April 2, 1914. Extract of Inaug. Dissertation, Freiburg, 1918.)—Substances whose number of free electrons per unit volume can be altered very considerably by temperature and other influences have been called variable conductors by Königsberger. Such substances show large Hall, Ettinghausen, Nernst, and Leduc effects, and are thus suitable for testing the electron theory of these effects. Again they show enormous deviations from Wiedemann and Franz's law, and if it is not permissible to apply the thermodynamical relations to metals because of the irreversibility introduced by heat conduction it will be less so for these substances. The substances used were molybdenum sulphide, silicon, and graphite. The Peltier-effect against copper (P) was measured by a method similar to that used by Barker [see Abstract No. 188 (1914)] with certain modifications as the specimens could only be obtained as short, thick bars. The thermoelectric power (E) against copper was measured. The relation $E = -P/T$ was found to hold within the limits of experimental error. The equation between the specific heat of electricity and dE/dT was only found to hold qualitatively, the deviations being of the same order of magnitude as for metals. It is thus concluded that the deviations for metals, and in fact for any substance, are not due to irreversibility produced by heat conduction, and hence the thermodynamical relations are valid, the deviations from them being experimental or due to some undiscovered effect. In spite of the large Hall-effect of variable conductors, its accurate measurement involves great care, for the Ettinghausen-effect accounts for a lateral temperature difference which produces thermoelectric currents. This can be eliminated in metals by using wires of the same material as the substances used. Both effects were measured in one series of experiments by having two wires (iron, eureka) from each lateral electrode to the galvanometer, and

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finding the current first with iron wires then with eureka. The results were in support of the electron theory as developed by Königsberger : (1) That the sign of the Hall-effect is opposite to that of the Thomson-effect ; (2) that the ratio of resistance to Hall-effect is approximately a constant for substances which are only weakly para- or dia-magnetic. J. R.

1121. *Sudden Disappearance of the Ordinary Resistance of Tin, and the Superconducting State of Lead.* **H. K. Onnes.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 678-688, Jan. 29, 1914.)—Further information is now given relative to the superconducting state in pure tin [see Abstract No. 880 (1914)], and the investigation is extended to include lead and also amalgamated tin-foil. The sudden disappearance of resistance in the case of tin takes place at $8\cdot806^{\circ}$ K., the ratio of the resistance at $8\cdot8^{\circ}$ K. to that of 278° K. being $< 10^{-7}$; a threshold resistance is also observed, as with mercury. Thin wires (not circular) of lead, obtained by paring on the lathe, as in the case of tin, were also examined. The lead became superconducting, when immersed in liquid He, without it being necessary to reduce the pressure at which the helium boiled ; at $4\cdot29^{\circ}$ K. the lead remained superconducting. It is not possible to say whether the resistance disappears suddenly, for there is as yet no satisfactory cryostat for the range from 14° K., where lead has its ordinary high resistance, down to $4\cdot3^{\circ}$ K., where the resistance has vanished. A threshold value for the current density in lead (bare wire $0\cdot025$ mm.² section) showed that this is > 420 and < 940 amps./mm.², at $4\cdot25^{\circ}$ K. The phenomenon of superconductivity is then considered as regards its application in the production of resistanceless coils, having a great number of windings in a very small compass. The possibilities and limitations with ordinary conductors are first pointed out, Perrin's and also Fabry's conclusions being quoted, and it is then shown that with superconductors, assuming no detrimental effect due to the magnetic field produced, a coil with 9000 amp.-turns per cm. could be obtained by using a lead wire of $1/70$ mm.² section and winding this so that 1000 turns are obtained in 1 cm. in a layer 1 cm. thick (radial depth) ; resistance at ordinary temperature, 778 ohms. A current of 0·8 amp. could be sent through this, when in the superconducting state, without the threshold value being reached. L. H. W.

1122. *Dielectric Constants of Vapours.* **G. Pohrt.** (Ann. d. Physik, 42. 8. pp. 569-584, Oct. 16, 1913.)—Gives tables of results obtained by means of a method proposed by the late P. N. Lebedew, employing a Wheatstone bridge in which the balance that is disturbed by change in capacity due to change in pressure, is obtained again by shift of the slide-wire. L. H. W.

1123. *Resistivity of Molten Gold.* **E. F. Northrup.** (Frank. Inst., Journ. 177. pp. 287-292, March, 1914.)—At 20° C. gold is found to have resistivity of $2\cdot816_{\pm}$ microhms-cm. The method of measurement is similar to that described in Abstract No. 491B (1914). The material of the container must be fired to a temperature higher than that at which the measurement of resistivity of the molten metal is to be determined ; otherwise there is contamination and error. At 1000° C. the gold was still solid, and its resistivity had become $12\cdot54$. At 1068° C. the resistivity increased from $18\cdot50$ to $30\cdot82$, as the gold melted. A curve is given, but its interpretation is reserved for a further paper. R. A.

1124. *Alteration of Electrical Resistance of Wires when subjected to Tension and Torsion.* **F. Credner.** (Zeitschr. Phys. Chem. 82. p. 457, 1918. Zeitschr. VOL. XVII.—A.—1914.

Instrumentenk. 84. pp. 98-95, March, 1914.)—The increase which takes place in the electrical conductivity of metal wires under tension when raised to a temperature of about 500°C . is often explained by the assumption that there are two modifications of the metal, one amorphous, the other crystalline; the amorphous variety having the higher specific resistance. It is assumed that, by heating, the metal passes from the amorphous to the crystalline state. To this explanation Tammann has offered objections based on thermodynamical grounds. According to his theory three factors must be considered as tending to alter the conductivity: The formation of spaces between the individual crystalline units of the metal; the alteration of the structure of the metal cylinders in the case of wires under tension from an irregular to a suitably arranged system of crystallites; formation of spaces on the gliding surfaces of the metal. The present experiments show that in the temperature interval 100° to 800°C . the resistance at constant temperature sinks so much the quicker and further the higher the temperature. From a known temperature—which for Au is about 270°C ., for Ag and Cu about 400°C .—a slow increase in the resistance begins. The minimum value of the specific resistance is reached at this temperature. An explanation of these facts according to Tammann's hypothesis is given. It is also found that the temperatures at which wires must be kept for 8 minutes in order to ensure the max. degree of conductivity are as follows: for Au and Ag, 480° ; for Cu, 450° ; for Ni, 550° ; for Fe, 600°C . The results of these experiments help to confirm Tammann's views on the subject.

A. E. G.

1125. *Electron Atmosphere (?) of Metals*. C. R. Englund. (Phil. Mag. 27. pp. 457-458, March, 1914.)—R. W. Wood advanced a theory of an electron atmosphere to account for some results which he obtained [see Abstract No. 865 (1918)]. In the present work measurements of the sparking potentials between silver, nickel, and soft-steel electrodes, one plane and the other having a radius of 1 cm., from $\frac{1}{4}$ to 4 sodium wave-lengths apart, were made. The air film in every case remained an insulator until the voltage reached the sparking potential, when a charge passed over to the electroscope. It would thus seem that the hypothesis of an electron atmosphere is untenable.

E. H. B.

1126. *Characteristics of Crystal Rectification*. A. E. Flowers. (Phys. Rev. 3. Ser. 2. pp. 25-46, Jan., 1914.)—In view of the peculiarities noticed [see Abstract No. 148 (1910)] it seemed desirable to subject crystals to very low and very high frequencies to see if time or energy were required to build up a resisting film upon change of current to the direction giving the higher resistance. Also it seemed desirable to determine the magnitude of the rectification at the high frequencies used in wireless telegraphy. The low frequencies used in the present investigation were $60 \sim$ and $2000 \sim$; the oscillations ranged from 10^4 to $6.8 \times 10^5 \sim$ per sec.

The results obtained are summarised briefly by the author as follows:—
 (1) The rectification at high frequency tends to be greater than at low frequency with the larger currents, and but very little different for small currents. (2) For very small currents the rectification tends to disappear, particularly for large contact areas and low current densities. (3) The rectification ratio for small currents is nearly proportional to the square of the rectified current and nearly proportional to the first power of the total or R.M.S. current. (4) Even very large contact areas will rectify well with large currents. (5) The rectification *ratio* for very small currents may be improved by the use of very small contact points, but a much larger potential is

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required to get the same amount of current. (6) The current density must be equal to or greater than a given minimum value for good rectification. (7) Resistance in series with the galena crystal rectifier greatly decreases the rectification ratio even for the same potential difference on the terminals of the rectifier. At 2.5 volts the rectification ratio was 61 % at 60, ∞ and 68 % at 180,000 Ω .
L. H. W.

1127. *Production of Critical Damping in a Moving Coil.* P. E. Klopsteg. (Phys. Rev. 2. Ser. 8. pp. 121-125, Feb. 1914.)—Assuming that the coil moves in a uniform field, two equations are developed for finding the proper size of wire to be used in damping rectangles, in order that critical damping may be obtained in moving-coil galvanometers. One equation is for use when the number of turns in the coil cannot be ascertained; the second when this number is known. It is suggested that manufacturers be requested to furnish, with their galvanometer coils, the values of the moment of inertia, number of turns and mean area of the coils. [See also Abstract No. 551 (1914).]

G. E. A.

1128. *The Moving Coil Ballistic Galvanometer.* R. L. Jones. (Phys. Soc., Proc. 26. pp. 75-81; Discussion, p. 81, Feb., 1914.)—The author first considers the mathematical theory of a moving coil galvanometer in which the damping is such as to make the motion non-oscillatory; then an account is given of some observations on a galvanometer which confirm some of the deductions from the theory, and the results obtained are applied to find the relation between the galvanometer throw and the change of flux in the search coil which produces it.

AUTHOR.

1129. *Dielectric Constant of Air up to 850 Atmospheres' Pressure.* A. Occhialini and E. Bodareu. (Ann. d. Physik, 42. 1. pp. 67-98, Aug. 26, 1913).—The full paper corresponding to Abstract No. 1496 (1913).

1130. *Rails and Slider Magneto.* A. Gray. (Phil. Mag. 27. pp. 428-432, March, 1914.)—The author points out the almost universal neglect of the variation of the self-inductance in this apparently simple apparatus, and develops the requisite correction to the mathematical theory, noting also that the apparently less simple disc magneto is really more so, in that its self-induction is unchanged by the rotation.

G. W. DE T.

1131. *A Water Model of the Musical Electric Arc.* W. Duddell. (Phys. Soc., Proc. 26. p. 117, Feb., 1914.)

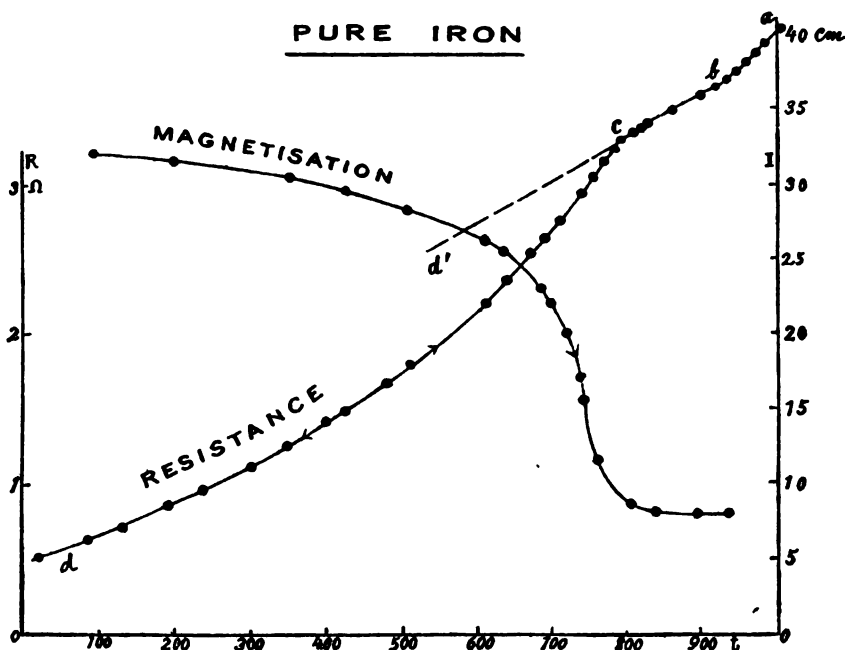
ALTERNATING CURRENTS AND MAGNETISM.

1132. *Permanent Magnets and Dynamical Theory.* A. Gray. (Phil. Mag. 27. pp. 432-435, March, 1914.)—Kelvin's conclusion [*Electrostatics and Magnetism*, p. 571, note] that the "mechanical value" of a current in a closed conductor is not affected by neighbourhood of permanent magnetism looks as if it must be inconsistent with the Amperean theory of permanent magnetism. The mathematical theory of a number of battery circuits in the field of a system of permanent magnets shows that, for a current system of moderate amount compared with the molecular current system, the effect, if any, of a configuration change in the former will be very small—this is a matter of observation. The effect of the magnets must be sought in the opening of the current circuits, and the effect, if any, of the annulment of terms expressing

the interaction of current system and magnets will consist in a change in the magnets. For when the circuits are opened the tubes of magnetic induction through the circuits produced by the magnets are not changed (except in so far as the magnets are changed by the withdrawal of the tubes thrust through the molecular circuits by the battery circuits); they remain *in situ*, none of them cross the wires. The tubes, however, which the battery circuits have linked through the molecular circuits shrink and disappear, and cross these latter circuits in doing so. If practically no change in molecular currents, $\Sigma \Sigma M\gamma$ must be small in comparison with $\Sigma(L'\gamma')$, where γ refers to the battery current system and γ' to the molecular current system. Thus any change in a γ' , due to the opening, must be of a small quantity of the order $M\gamma$ in magnitude, so that considering the exceedingly great number of molecular circuits in an ordinary magnet on the Amperean theory, the dynamical value of a current in a conductor will not be appreciably affected by the presence of permanent magnets. G. W. DE T.

1133. *Change of Magnetisation and Electric Resistance in Iron, Steel, and Nickel at High Temperatures.* K. Honda and Y. Ogura. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 281-289, Feb., 1914.)—The above metals

$l = 1120$ cm. $2r = 0.71$ mm. $H = 160$



were formed into wire grids, which were held in cylindrical form by means of asbestos-paper binding. They were then tested simultaneously as regards resistance and magnetisation (by a magnetometric method) at different temperatures. The course of the phenomena is similar in iron and nickel. The nick *c* on the resistance-temperature curve *dcb* is considered as indicating

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the end of the change of resistance caused by the ferromagnetic property of the metal (see diagram). No change was noted in the resistance of steel wires during the small magnetic change which takes place between 100° and 200° . Honda's view, that the magnetic or α - β change is not a phase transformation but a progressive change in the property of a phase with temperature, is confirmed by the experiments. G. E. A.

1134. Cross Magnetisation made Visible. E. Liebreich. (Deutsch. Phys. Gesell., Verh. 16. 6. pp. 807-814, March 30, 1914.)—Faraday, and later Donle, demonstrated that permanent cross-magnetisation of a thin plate of iron or steel was practically impossible. In dealing with the magnetisation involved in the Poulsen telegraph, the author has used a method of rendering visible the fine details of local longitudinal magnetisation. The iron or steel plate was first put in contact with a magnet, and then powdered with iron powder (*ferrum hydrogenio reductum*). The powder was knocked off, leaving only the very finest iron dust behind, and the plate then placed for a few minutes in a bath of chromic acid. The magnetised spots became dark red on a yellowish-red background. The equations representing the presumed chemical action are given along with further details of the method. G. E. A.

1135. Magnetic Properties of Iron and Nickel. J. R. Ashworth. (Phil. Mag. 27. pp. 857-870, Feb., 1914.)—This is the first part of a paper on the magnetic behaviour of Fe and Ni when the effects of hysteresis are largely got rid of by using an alternating current. The magnetometric method was used in the experiments. A continuous current could be applied to the solenoid and the alternating current used to annul hysteresis had a frequency of 88 per sec. In iron an alternating current of 1 virtual amp. was found to be sufficient to reduce the hysteresis to a negligible quantity without appreciably lowering the intensity of magnetisation at ordinary temperatures. Stronger alternating currents are required to suppress hysteresis in nickel, and a current of 2 virtual amps. or even currents twice as strong did not suppress hysteresis altogether. An account is given of the investigation of the law of inverse relationship between strength of alternating current and intensity of magnetisation; of the construction of anhysteretic isothermals and isodynamics for iron and nickel; and of the suppression of the critical temperature in Ni. The author considers the experiments indicate that it is unlikely that the critical temperature is due to a chemical or allotropic modification of the metal. Some of the curves obtained point to the occurrence of a gradual change from ferromagnetic to paramagnetic properties. As a first approximation the equation to the anhysteretic isothermals may be written $H(1/I - 1/I_0) = R'T$, T being the absolute temperature. When I is very small the term $1/I_0$ may be neglected and the equation then becomes $H/I = R'T$ or $KT = 1/R'$. P being the constant occurring in Fröhlich's equation $H(1/I - 1/I_0) = P$, $R' = P/T$, and K is the susceptibility. This is Curie's paramagnetic equation in which $1/R'$ is equivalent to his constant A . But there appears to be another field of force in action besides the external field, and this is probably due to the magnetisation of the material itself and is some function of the intensity. The equation would then take the form $(H + f(I)/I - 1/I_0) = R'T$. Thus it recalls the equation of van der Waals for fluids, field strength and magnetic intensity taking the place of pressure and density. Since the effects of temperature on magnetism are found to be like those due to an alternating current setting up a

magnetic agitation, it appears more probable that the former are kinetic effects of thermal agitation. J. J. S.

1136. *Electromagnet to give a Field of 100,000 Gauss.* H. Deslandres and A. Perot. (Comptes Rendus, 158. pp. 659-664, March 9, 1914.)—By increasing the dimensions of the apparatus described in a former paper [see Abstract No. 756 (1914)] the authors hope to be able to produce a field of 100,000 gauss. G. E. A.

1137. *Susceptibility of Feebly Magnetic Alloys.* E. L. Dupuy. (Comptes Rendus, 158. pp. 798-794, March 16, 1914.)—Measurements were made by the use of Faraday's method in which the specimen is suspended between the poles of a strong electromagnet. The effect on the specimen was neutralised by an electromagnetic method similar to that of Weiss and Foex. The Sb-Ag susceptibility diagram has three angular points corresponding to the compound Ag-Sb and to two saturated solid solutions of this compound in Ag and in Sb respectively. The results for Pb-Sn agree with those of Honda and Sone. A diagram is also given for Al-Zn. In these alloys the susceptibility varies according to a linear law when the two constituents form a simple mixture; the variation is irregular for solid solutions; and definite compounds have definite susceptibilities. G. E. A.

1138. *Anomalous Temperature Effects in Magnetised Steel.* N. H. Williams. (Phys. Rev. 8. Ser. 2. pp. 115-120, Feb., 1914.)—A description of work undertaken to obtain further data on the anomalous magnetisation described by Smith and Guild [Abstract No. 1899 (1912)]. The experiments point to the conclusion that the outer layer of the steel rod is harder than the interior portions, and that the effect, on this layer, of the oscillatory current in the magnetising coil at break, in conjunction with the demagnetising field due to the ends of the rod, may produce a reversal of magnetism in the outer layers of the rod. G. E. A.

1139. *Ferromagnetic Manganese Phosphides.* S. Hilpert and T. Dieckmann. (Ber. Deut. Chem. Gesell. 47. 4. pp. 780-784, March 7, 1914. Chem. News, 109. p. 215, May 1, 1914. Abstract.)—The authors and O. Hauf heat 2 gm. of manganese and 2.4 of red phosphorus in an exhausted tube of Jena glass to 400°, and then to 600°, each time for 48 hours. The product extracted with benzene, alcohol, and ether, leaves a darkish-grey substance MnP₂, which is not attacked by acids free of oxygen, but slowly decomposed by nitric acid. Heated in a hydrogen current at 290° it remains constant; at 400° part of the phosphorus distils over, and the phosphide MnP (described by the authors in 1911) is left, which resembles the higher phosphide in appearance and reactions. Both these phosphides, as well as others previously prepared, Mn₂P₃ and Mn₃P₄, are ferromagnetic, the Curie point of the MnP₂ lying about 88°, that of the MnP about 26°. These temperatures are very low. H. B.

1140. *Modification in the Cryomagnetic Apparatus of Kamerlingh Onnes and Perrier.* E. Oosterhuis. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 892-894, March 26, 1914. Communication No. 189b from the Phys. Lab., Leiden.)—The electromagnetic method of compensating the magnetic force on the specimen [see Abstract No. 969 (1914)] is here replaced by a compensation by means of weights. G. E. A.

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1141. Susceptibility of Solid Oxygen in two Forms. A. Perrier and H. K. Onnes. (Konink. Akad. Wetensch. Amsterdam, Proc. 18. pp. 894-901, March 26, 1914. Communication No. 189c from the Phys. Lab., Leiden.)—Solid oxygen, besides appearing in the blue-grey form, also occurs in a transparent vitreous form. The method of obtaining a solid rod of oxygen having been detailed, the following results are given. The transition from the transparent modification of oxygen to the opaque, which takes place at about -225°C ., is not accompanied by any conspicuous magnetic change. Also in the whole range from the freezing-point of oxygen down to about -240°C . the susceptibility is markedly less than in the liquid state. At about -240°C . the susceptibility suddenly falls to about half its value, viz. from 166.1×10^{-8} to 79×10^{-8} . There are thus two great changes in the susceptibility of oxygen, one a drop to $\frac{1}{2}$ at freezing, and the other to $\frac{1}{2}$ at -240°C . Oxygen therefore is a new example of a substance that follows Curie's law at a higher temperature, and on approaching the absolute zero completely deviates from it. G. E. A.

1142. Susceptibility of Liquid Mixtures of Nitrogen and Oxygen. A. Perrier and H. K. Onnes. (Konink. Akad. Wetensch. Amsterdam, Proc. 18. pp. 901-916, March 26, 1914. Communication No. 189d from the Phys. Lab., Leiden.)—A determination of the susceptibility of liquid mixtures of O and N was made for the purpose of gauging the influence of the distance of the molecules on the deviations from Curie's law. The following conclusions are drawn from the experimental results: The specific magnetisation coefficient of oxygen becomes greater in proportion as the concentration diminishes, i.e. the additive rule is by no means followed in mixtures of O and N. With increasing dilution, the magnetisation coefficient approaches to the values which satisfy inverse proportionality to the absolute temperature, starting from Weiss and Piccard's value for gaseous oxygen. The deviations from the Curie-Langevin law shown by pure O. at low temperature are not an immediate consequence of the change of temperature, but are caused by the increase in density, that is, by the distance between the molecules becoming smaller. Further, when $1/\chi$ is plotted with T , the points obtained for different concentrations lie on parallel straight lines. The change can therefore be represented by a relation of the form $\chi(T + \Delta) = \text{const.}$, in which only Δ changes from one concentration to another. The change in the density of oxygen therefore only alters the specific magnetisation without changing the Curie constant. It is considered that Langevin's theory, supplemented by the hypothesis of negative molecular fields, is sufficient to explain the phenomena, and that the molecular field of oxygen changes nearly proportionally to the density. [See also preceding Abstract.] G. E. A.

1143. Magnetic Susceptibilities of the Elements. F. H. Loring. (Chem. News, 109. pp. 121-128, March 18, and pp. 188-184, March 20, 1914.)—A general account is given of magnetic susceptibility and of its relation to permeability, and an attempt is made to bring the magnetic properties of the elements into systematic relationship by making use of the arrangement of the elements previously developed by the author [see Abstract No. 98 (1914)]. T. H. P.

1144. Extension of Mayer's Experiment with Floating Magnets. E. R. Lyon. (Phys. Rev. 8. Ser. 2. pp. 282-288, March, 1914.)—Describes experiments with floating magnets illustrating J. J. Thomson's theory of the atom. Instead of
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a large magnet to attract the little magnets, a coil wound round the circular tank was used. Systems up to 75 floating magnets were tried, and results were obtained which accord with Mendelejeff's grouping of the elements.

Still larger groups are to be investigated.

E. H. B.

1145. *Hysteresis at High Frequencies.* A. Schidlof and Mlle. A. Albert. (Archives des Sciences, 87. pp. 117-182, Feb., 1914.)—Repetition of a previous research [see Abstract No. 1510 (1918)] with greater accuracy. The results confirm the conclusion of Guye and Albert that the loss of energy is independent of the speed of describing the hysteresis cycle. [See also Abstract No. 550 (1914).]

G. E. A.

1146. *Theory of the Earth Inductor as an Inclinator.* N. E. Dorsey. (Terrestrial Magnetism, 18. pp. 1-88, March, 1918.)

1147. *The C.I.W. Deflector in use on the "Carnegie" for determining the Magnetic Horizontal Intensity and the Magnetic Declination at Sea.* L. A. Bauer and J. A. Fleming. (Terrestrial Magnetism, 18. pp. 57-62, June, 1918.)

1148. *Absolute Susceptibility of Liquids.* W. J. de Haas and P. Drapier. (Ann. d. Physik, 42. 8. pp. 678-684, Oct. 16, 1918.)—The full paper corresponding to Abstract No. 690 (1918).

1149. *Magnetic Declinations and Chart Corrections obtained by the "Carnegie" from St. Helena to Falmouth, England, July to September, 1918.* L. A. Bauer and W. J. Peters. (Terrestrial Magnetism, 18. pp. 161-162, Dec., 1918.)

RADIOLOGY AND ELECTROPHYSIOLOGY.

1150. *New Methods of Localisation of Foreign Bodies by Röntgen Rays.* G. Réchou. (Archives d'El. Médicale, 22. pp. 75-91, Jan. 25, 1914.)—The three methods described are those of Mazères, Furstenuau, and Laroquette. The geometrical principle on which each of these methods is based is first of all explained in detail, then full descriptions of the procedure in each case is given, together with any slight necessary addition to the general explanation. In each of the methods use is made of the images of some object placed on the body of the patient, and the displacement of this image, as compared with that of the foreign body, is the fundamental measurement required. The tube used is either one of ordinary type, in which case a movement of the tube in a plane parallel to that of the photographic plate must be arranged, or a tube of the spectroscopic type. Special compasses for performing the measurement of displacements are also described.

A. E. G.

1151. *Three Practical Methods of Localisation of Foreign Bodies with or without a Compass.* Mazères. (Archives d'El. Médicale, 22. pp. 281-292, March 25, 1914.)—The three methods described allow an automatic localisation, a localisation by varying the height of the bulb, and a manipulation by graphical means, neither instruments, tables, nor scales being required. The three methods verify each other, and the radiographic and mental work is reduced to a minimum. The theory common to all three methods is dealt with in detail.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1152. Application of the Laws of Transparence of Matter to Röntgen Rays to the fixing of some Contested Atomic Weights. **L. Benoist and H. Copaux.** (*Comptes Rendus*, 158. pp. 689-692, March 9, and pp. 859-860, March 28, 1914).—As a result of the verification of the laws of transparence of matter in the case of complex minerals [see Abstract No. 869 (1914)] the method is now extended to carrying out control experiments in the determination of atomic weights of thorium, cerium, and glucinum. The method is based upon an absolutely intrinsic property of the atom and consists in determining the transparency equivalent of the element, experiments being made either upon the element itself or on one of its compounds. In the latter case the equivalent sought is deduced from that measured for the compound, those of the other components being known. The value obtained assigns to the element a certain position upon a general curve of isotransparence of the elements for the rays of the degree employed and, consequently, a certain atomic weight. A means of control is employed by comparing the element with those to which it is near, the comparison being made upon the value of the equivalent or upon the variations of transparence resulting from variations of radio-chromometric degree of the rays. This method has the advantage over those which are based upon the law of Dulong and Petit and those of a similar class, in being entirely independent of all conditions which bring about variations in the physico-chemical properties. In the case of thorium according as the normal valency is considered as 2 or 4 the atomic weight ought to be 116 or 232. It is shown that the transparence is compatible with an atomic weight 232, and this is confirmed by a direct comparison with Pb. With cerium the question to decide is whether the more probable atomic weight is 92 or 140.25. By a comparison of its equivalent of transparence with those of Zr, Mo, Ba, and La, it is concluded that the results are in favour of an atomic weight of 140.25 for Ce. Glucinum may, if bivalent, be considered to have an atomic weight 9.1, and if trivalent, one of 18.7. The present experiments give results in favour of the former. A. E. G.

1153. Change of Form of Liquid Crystals caused by a Molecular Transformation. **O. Lehmann.** (*Comptes Rendus*, 158. pp. 889-898, Feb. 9, 1914).—In the "formes myéliniques" of ammonium oleate there exists a structure which is neither amorphous as in liquids nor reticular as in crystals: the molecules appear to be arranged in circles round an axis, so that points on and off the axis are not equivalent, nor is the axis itself equivalent to other lines parallel to it. Under a microscope these forms show curved filaments, whilst in the crystals the lines are all rectilinear; by varying the temperature above and below -4° the lines become curved and straight alternately; e.g. on cooling below -4° a perfect circle may be seen to become polygonal. Similar observations can be made with "protagon," a mixture of cerasine and phrenosine studied by O. Rosenheim and C. Tebb in the Physiological Laboratory at King's College, London. T. M. L.

1154. Absorption of Gases by Charcoal at Low Temperatures. **G. Claude.** (*Comptes Rendus*, 158. pp. 861-864, March 28, 1914).—It is usually accepted
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as a general rule that the more easily a gas is liquefied, the more readily it is absorbed by charcoal [see Abstract No. 1658 (1908)]. Some observations of the author in connection with the filling of tubes with neon indicated that hydrogen was abnormal with respect to its absorption by charcoal, and he has consequently determined the amounts of various gases absorbed by 100 gm. of coconut charcoal at various pressures. With hydrogen, neon, and helium the temperature was -195.5° , and with nitrogen -182.5° . The absorption of the hydrogen was found to be abnormal, much larger quantities being absorbed than of neon. Helium is the least readily, and nitrogen the most readily absorbed. T. S. P.

1155. *New Chemist's Slide-rule.* H. R. Lee. (Metallurgical and Chem. Engin. 12. pp. 201-202, March, 1914.)—A description of a new type of slide-rule designed to meet the needs of chemists engaged in commercial analysis. The regular or front side of the rule shows the molecular symbols of 46 salts and 10 acids and bases on the A scale of the frame and a parallel list of these on the B scale of the slide. On the back appear the symbols of 42 elements and 87 oxides in place of the usual A scale on the frame, and a parallel list of these on the B1 scale of the slide. The C and D scales on the front and the C1 and D1 scales on the back are graduated numerically, as is usual on the engineers' slide-rule. The results obtained with the rule are of as high order of accuracy as the chemical work, which precedes its use, is usually expected to be. T. S. P.

1156. *Gran-Annular Electric Furnace.* Z. Jeffries. (Metallurgical and Chem. Engin. 12. pp. 154-157, March, 1914.)—The furnace of C. H. Fulton and W. A. Coursen consists essentially of two concentric tubes (of alundum or magnesia) forming an annular chamber for the granulated resistor—kryptol, carbon of the Carbon Co., or graphite of the Acheson Co. The crucible is stored within the inner tube, whose diameter is 2 in. The tubes are embedded in heavy graphite plates, to which the terminals are attached; outside are powdered magnesia and asbestos. From measurements made in such a furnace with the aid of thermo-couples it follows that the three resistor materials mentioned have all a negative temperature coefficient; in the kryptol the resistance dropped from 8.8 ohms to about 1 ohm per cub. in. as the temperature was raised to 1500° C., in the carbon from 5 to 0.5, in the graphite from 1.8 to 0.6; in the last case particularly the small fall of resistance with rising temperature seems mainly to be due to the better contact between the grains consequent upon expansion. A special rheostat for working the furnace on 110-volt circuits is also described. The resistance is increased by each heating, owing to the oxidation of some carbon, and the material has to be renewed after about 40 heatings up to 1500° C. H. B.

1157. *Preparation of Colloidal Sulphur and Selenium.* J. Meyer. (Ber. Deut. Chem. Gesell. 46. 18. pp. 8089-8091, Oct. 25, 1913. Chem. News, 108. p. 806, Dec. 19, 1913. Abstract.)—During his determination of the atomic weight of selenium, J. Jannek (Ibid. 46. p. 2876) observed that SeO_2 in aqueous solution is reduced only by highly diluted (not by concentrated) hydrazine hydrate; Se is very slowly precipitated in the red colloidal modification which quickly changes into the grey crystalline modification. When Se is dissolved in concentrated hydrazine hydrate, the author finds, it forms a viscous reddish solution which on high dilution yields an extraordinarily stable solution, which may even be boiled and be acidified; on long standing a little red Se

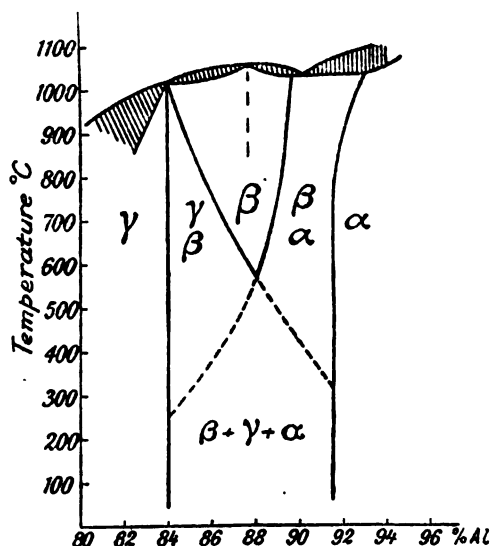
falls out, which redissolves on shaking. Sulphur behaves similarly and yields a lemon-coloured solution, which turns yellowish-white, of colloidal sulphur; this solution is not quite so stable as that of selenium, and neither solution can be dialysed. The chemistry of these solutions is complicated, colourless sulphide (or selenide) and polysulphides being formed. H. B.

1158. *Decomposition of Gaseous Ammonia by Radium Emanation; Temperature Influence.* E. Woultzel. (Comptes Rendus, 158. pp. 571-578, Feb. 28, 1914.)—The decomposition of H_2S -gas by radium emanation decreases when the temperature rises [see Abstract No. 764 (1914)]; this could be due to several reasons, one of them being that the recombination is favoured by higher temperature. To investigate this question the practically irreversible decomposition of NH_3 was studied. Only nitrogen and hydrogen are produced. Increased pressure (up to 7 atmos.) favours the decomposition, merely, it would appear, because it facilitates the absorption. The quantity of ammonia decomposed per curie of emanation was 8 times as large as that found by Usher, but 5 times less than that found by the author for H_2S . Elevation of temperature decidedly favours the decomposition; the quantities decomposed at ordinary temperature, 108° , and 220° were in the ratio 1 : 2 : 8. H. B.

1159. *Alloys of Copper, Nickel and Aluminium.* L. Guillet. (Comptes Rendus, 158. pp. 704-706, March 9, 1914.)—Gives briefly the results obtained by the examination of the alloys resulting from the addition of Al to copper-nickel alloys. The results of mechanical tests on three series of alloys are given. The first series comprises alloys containing 60 % Cu, 80 to 40 % Ni, and 0 to 10 % Al; the second series, 88 % Cu, 5 to 17 % Ni, and 0 to 10 % Al; and the third series, 90 % Cu, 0 to 10 % Ni, and 0 to 10 % Al. From the results it is seen that the addition of small quantities of Al improves the mechanical properties of copper-nickel alloys. The tensile strength and hardness increase in value with additions of Al up to a maximum. This maximum occurs in the alloys with higher Al-contents, the lower the amount of copper present. A note is added on the microstructure and the effect of treatment on the alloys. C. O. B.

1160. *Fusion and Volatilisation of Refractory Oxides in the Electric Vacuum Furnace.* O. Ruff, H. Seiferheld, and J. Suda. (Zeitschr. anorgan. Chem. 82. pp. 378-400, 1913. Tonindustrie Zeitung, 87. pp. 1698-1694, Oct. 30, 1913. Amer. Soc. Mech. Engin., Journ. 86. p. 05, Jan. 1914. Abstract.)—The melting-points of most refractory materials depend in a carbon furnace much upon the furnace atmosphere; only alumina, melting-point $2010 \pm 10^\circ \text{C.}$, is for this reason suitable for calibration purposes. Beryllium (glucinum) oxide stands next to alumina in that respect; it melts at 2525° under reduced pressure (10 to 80 mm.), but volatilises before melting. Zirconia is readily reduced to a lower oxide of melting-point 2585° , which is fairly independent of the atmosphere and the rate of heating, the vapour pressure being low. Magnesia melts above 2500° , but reacts too readily with carbon to allow of a definite temperature-determination. Lime reacts with nitrogen as well; it begins to volatilise about 2000° , though it does not melt at 2450° under reduced pressure. Stannic oxide melts in zirconia at 1625° under violent reduction. Titanium oxide is converted into Ti_2O_3 ; the oxides of tantalum and chromium are reduced to lower oxides; yttria, ceria, thoria, and lanthana are converted into carbides H. B.

1161. *Copper-Aluminium Alloys containing 84 to 90 per cent. Copper.* H. Hanemann and P. Merica. (Int. Zeitschr. Metallg. 4. pp. 209-227, 1918. Rev. de Métallurgie, 11. pp. 86-88, Feb., 1914. Extract.)—Although the alloys of copper and aluminium have been pretty well studied, the Cu-rich ones present certain difficulties which the authors have endeavoured to clear up by a metallographic study of annealed and quenched samples. In the range tested (84·7 to 91·8 % Cu), these alloys present features very similar to those observed in quenched and annealed steels. Acid ferric chloride solution attacks the constituents in the order, α , β , γ , while ammoniacal cupric chloride attacks them in the reverse order. Slowly cooled samples show α on a groundwork of $\gamma + \alpha$ eutectoid, the structure not being affected by



prolonged annealing at 485° C. On rapid cooling α separates in long needles similar in appearance to the acicular ferrite sometimes developed in hypo-eutectoid steels. After slow cooling, samples hypo-eutectoid with respect to Al show large needles of γ in a ground mass of $\alpha + \beta$ eutectoid. More rapid cooling develops the γ in the form of star-shaped crystals. Quenching experiments show that the rate of crystallisation of these alloys is very high. Quenched alloys with 84 to 86 % Cu show large plates of β with localised crystallisation of γ . The general structure indicates that β crystallises in the regular system. Between 86 and 88 % Cu the structure consists of γ with an acicular constituent, while above 88 % Cu there are indications of the β splitting up into $\alpha + \gamma$. The observed phenomena are summed up by the accompanying diagram.

F. C. A. H. L.

1162. *Preparation of Sections of Fractures.* A. Campion and J. M. Ferguson. (Iron and Steel Inst., Journ. 88. pp. 885-888; Discussion, pp. 889-891, 1918. Engineering, 96. p. 890, Sept. 19, 1918. Mech. Eng. 82. pp. 295-296, Sept. 26, 1918.)—Particulars and examples are given of the method of making of a microscopic section through a fracture of a piece of steel in which a fusible alloy is cast in contact with the fracture surface and allowed to solidify there, so that in the cutting and polishing processes support is given

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at the edge of the steel, thus preventing the rounding of the edge and permitting of examination to the extreme edge of the section of the fracture. The preferred fusible alloy consists of : Bi, 50 ; Pb, 80 ; Sn, 25 ; and Zn, 8 per cent. The fracture to be examined is dipped successively in HCl solution of 1.1 sp. gr., then "killed spirits," then in the molten alloy, where it is held until it ceases to cause solidification of the alloy. After cooling the section can be cut through the steel and the alloy as desired. F. R.

1163. *Arsenical Compounds of Cadmium.* S. F. Zemczuzny. (Zeitschr. f. Metallographie, 4. pp. 228-247, 1918. Rev. de Métallurgie, 11. pp. 88-91, Feb., 1914. Extract.)—In applying the methods of thermal analysis to this system it has been found impossible to prepare alloys containing more than 70 atoms per cent. As, owing to the volatility of As. The equilibrium diagram shows two maxima, one corresponding to Cd_3As_2 at $721^\circ\text{C}.$, and the other at $621^\circ\text{C}.$ corresponding to the compound CdAs_2 . Two eutectics, one consisting of practically pure Cd and the other (Cd_3As_2 — CdAs_2) containing 55.5 atoms per cent. As, are formed at 820° and $610^\circ\text{C}.$ respectively. The compound Cd_3As_2 undergoes a polymorphic transformation at $578^\circ\text{C}.$ Since the compound CdAs_2 readily supercools it has been found possible to follow a metastable branch of the curve showing a Cd_3As_2 —As eutectic at $526^\circ\text{C}.$ and containing 62.5 atoms per cent. As. These results have been confirmed micrographically and by a study of the densities and atomic volumes. Cd_3As_2 has a density of 6.25 and a hardness somewhat less than 8.5 on Moh's scale, while CdAs_2 has a density of 5.86 and a hardness of 8.5. The hardnesses of Cd and As on Moh's scale are 2 and 8.5 respectively.

F. C. A. H. L.

1164. *The Surface Tension of Mixtures. I. Mixtures of Partly Miscible Liquids and the Influence of Solubility. II. Mixtures of Perfectly Miscible Liquids and the Relation between their Surface Tensions and Vapour Pressures.* R. P. Worley. (Chem. Soc., Journ. 105. pp. 260-282, Jan., 1914.)—The author has determined, by the capillary rise method, the surface tension of solutions of aniline, phenol, and iso-butyl alcohol in water, at different temperatures, and points out that there is apparently a connection between the lowering of the surface tension of water and the solubility of the solute, the effect of addition of a solute to water being all the greater the lower the solubility of the solute. This behaviour the author finds confirmed also at higher temperatures.

In Part II. the author communicates the results of determinations of surface tension in the case of mixtures of benzene and ethylene dichloride, acetone and carbon disulphide, pyridine and acetic acid ; and from the results obtained puts forward the three rules : (1) If at any given temperature the vapour pressures of mixtures of two liquids agree with the values calculated by the rule of admixture in molecular proportions, then at that temperature the surface tensions of the mixtures agree with those calculated by the formula $S = V_1S_1 + V_2S_2$. (2) If the vapour pressures are greater than those calculated, then the surface tensions are less than those calculated. (3) If the vapour pressures are less than those calculated, then the surface tensions are greater than those calculated.

A. F.

1165. *Relationship between the Viscosity, Density, and Temperature of Salt Solutions.* W. J. Walker. (Phil. Mag. 27. pp. 288-297, Feb., 1914.)—Measurements of the viscosity of solutions of sodium chloride of different

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densities at 62.5° F. lead to the formula, $\mu = 0.00002265 + 0.0000428(\rho - 1) + 0.000228(\rho - 1)^2$, where μ represents the viscosity in F.P.S. units and ρ the specific gravity of the solution. With sodium and calcium chlorides it is found that, if μ/μ_0 is plotted against μ , where μ and μ_0 are viscosities at similar densities, an approximately straight line is obtained, so that $F(\rho) = A - B/\mu$. Putting this in the form $F'(\rho - 1) = A - B/\mu$, the value $\rho = 1$ gives $B = \mu'A$, where μ' is the viscosity of water at the temperature considered. Hence $F'(\rho - 1) = A(1 - \mu'/\mu)$. Tentatively it was found that $F'(\rho - 1)$ is of the form $(\rho - 1)^n$, where n lies between 1 and 2 for both solutions. On plotting $\log(\rho - 1)$ against $\log(1 - \mu'/\mu)$ practically straight lines are obtained, the values of n being 1.088 and 1.055 for sodium and calcium chlorides respectively. Measurements of sodium chloride solutions at 0°, 10°, 80°, 50°, and 100° C. show that n decreases proportionally with rise of temperature from 0° to 80°, after which its relative diminution is much less to 100°. Assuming n to vary regularly from 1.4 to 1.0 between 0° and 100°, the formula $(\rho - 1)^{1.4 - 0.004T} = A(1 - \mu'/\mu)$ is obtained for sodium chloride solutions. Similarly, the expression, $(\rho - 1)^{0.96 - 0.008T} = A(1 - \mu'/\mu)$, is deduced for calcium chloride solutions between 0° and 50°. To obtain the value of A , it is best to use the point at which the solution has its highest density; for sodium chloride, $\log A = 0.6790 + 0.00874T$, and for calcium chloride, $\log A = -0.8580 + 0.0005T$.

In some cases the viscosity at first diminishes to a minimum as the salt-content of the solution increases, and then increases as usual. This happens with ammonium nitrate, and it is here found that good agreement is given by the formula, $\pm(\rho - x)^n = A(1 - \mu'/\mu)$, where μ' is the minimum viscosity and where the negative sign is used when x , the density at the minimum viscosity point, is greater than ρ . One reason for the diminution of n with rise of temperature is that the particles of the solute become more nearly analogous to gas particles, i.e. move with greater freedom at the higher temperatures.

With water and mercury, $F(\mu)$ in the formula, $F(\mu) = a - b/T$, is not of the form μ^n . T. H. P.

1166. *Solubility of RaEm in Aqueous Salt Solutions.* M. Kofler. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1478-1479, July, 1918.)

1167. *Compressibility of Methyl Chloride.* E. Bodareu. (Accad. Lincei, Atti, 23. pp. 491-498, April 5, 1914.)—At 18.8° the variation of $p v$ with p for methyl chloride is shown by the following table:—

p	760	1200	1650	2100	2800
$p v$	1	0.9796	0.9648	0.9588	0.9885

T. H. P.

1168. *Constitution and Structure of the Elements.* H. Collins. (Chem. News, 109. pp. 26-28, Jan. 16, 1914.)—The paper deals with empirical relations between the atomic weights. It is concluded that Na and Zr take a prominent part in the formation of all elements of greater atomic weight than themselves. E. M.

1169. *Conductivity of Fluosilicic Acid and Lead Fluosilicate.* T. A. Patterson. (Metallurgical and Chem. Engin. 11. pp. 670-672, Dec., 1918.)—Tables are given showing: (1) The conductivity and equivalent conductivity of fluosilicic acid at 25°C.; (2) the temperature coefficient of the conductivity of normal and sixteenth-normal fluosilicic acid from 20-45°C.; (3) the conductivity of various mixtures of fluosilicic acid and lead fluosilicate at 25°.

T. S. P.

1170. *Hydrogen Electrode, Calomel Electrode, and Contact Potential.* C. N. Myers and S. F. Acree. (Amer. Chem. Journ. 50. pp. 396-411, Dec., 1918.)—Experiments have been made to establish the hydrogen-electrode as a standard instrument for measuring hydrogen-ion concentrations. Special attention is directed to the necessity of keeping the electrodes permanently wet after platinising ; of maintaining them in an *active* condition during the whole time when they may be required for use ; of saturating the system completely with hydrogen ; and of avoiding all impurities in the acid used in the cell. It was found possible to get the (17) electrodes to agree within 0.00001 volt. If a large number of cells are connected with each other through the mercury in the electrode tubes they very soon settle down to give identical and normal values, and may agree within 0.000008 volt. This method may also be applied to the calomel electrode, enabling new batteries to come to agreement within 0.00001 volt in about 2 days, where otherwise 5 days may be required. The constancy of the hydrogen electrode has been proved over a period of nearly two years, but there is a certain amount of lag in responding to changes of barometric pressure (0.001 atmo. \equiv 0.000025 volt). The calomel electrode, on the other hand, shows a gradual shift in its value as its age increases, at least up to a year. This is attributed to decomposition of the calomel, $\text{Hg}_2\text{Cl}_2 \rightleftharpoons \text{HgCl}_2 + \text{Hg}$, and experiments are in progress to test the effect of adding mercuric chloride to the new cells.

Bjerrum's "sand-filling" method was tried and found to be very satisfactory. T. M. L.

1171. *Electrostatic Determination of the Potential of an Electrolyte.* G. Borelius. (Ann. d. Physik, 42. 6. pp. 1129-1144, Dec. 23, 1918.)—Use is made of a novel potential multiplier, consisting of a fixed and a revolving system, turned by hand. Six copper sectors attached to an ebonite disc pass over a glass cylinder containing the electrolyte and over two insulated copper plates mounted in a zinc cylinder ; the rotating sectors touch the surface of the electrolyte and six brushes, which are joined to the zinc or to the plates and to a quadrant electrometer ; a compensation method is used, the electrode dipping into the electrolyte being charged until the electrometer is no longer deflected. With a Cu-electrode dipping into normal CuSO_4 solution, the electrolyte potential was first +0.2 volt, but it changed to -0.028 volt in an hour ; on diluting the normal solution to $\text{N}/2$, $\text{N}/2^2$, $\text{N}/2^3$, the potential steadily decreased to -0.088 volt, the ΔP being nearly constant. These values are not in accord with those of other observers, nor with Nernst's formula ; but the constants are the same, though of opposite sign. The author therefore suggests that not only the positive ions given off by the metals, but also the negative ions have to be taken into consideration in calculating single potentials. The paper also brings potential measurements of solutions of alkali salts, diluted in the above indicated way, KCl , KBr , KI , KCN against electrodes of various metals ; in normal KCN the voltaic series found was Al , Zn , Cu , Cd , Sn , Ag , Sb , Pb , Bi , which agrees with Poggendorff, 1848. Normal solutions of KNO_3 , K_2SO_4 , NaF gave with different metals almost the same potentials as with pure water ; the halide solutions gave more positive potentials. H. B.

1172. *Electro-deposition of Zinc at High-current Densities.* J. N. Pring and U. C. Tainton. (Chem. Soc., Journ. 105. pp. 710-724, March, 1914.)—At certain very high-current densities, the electro-deposition of zinc can be effected in the presence of a high concentration of free acid. Under these

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conditions the ratio of zinc to hydrogen liberated actually increases with the acid concentration up to a certain value, and also increases with the current density. In this way, with a concentration of sulphuric acid of about 15 gm. per 100 cm., and a current density of between 20 and 50 amps./dm.², zinc can be deposited with an efficiency of about 95 per cent. With lead anodes, this electrolysis is achieved with a p.d. of about 5 volts, and with zinc anodes, 8 volts. The presence of small quantities of colloidal matter exerts a marked effect on this reaction, and enables bright adherent deposits to be produced. Their presence also enables one to use a higher current density, and in this way yields a higher current-efficiency in the zinc deposition. In the solutions used a very strong retardation was observed in the deposition of iron present in the electrolyte, in all cases the amount of iron deposited with the zinc being very much less than the ratio of these metals in the electrolyte. On account of this considerable quantities of iron in the electrolyte caused very little contamination of the zinc. Experiments showed that the results obtained could not be entirely ascribed to effects of overvoltage, or surface tension, or viscosity of the electrolyte; they are probably mainly determined by influences which control the rate of the reactions involved in the change from the ionised to the free element. The results obtained by the authors indicate the most favourable conditions under which zinc can be obtained from commercial solutions, either with a view to the recovery of the metal or to its application for the purpose of electro-plating.

T. S. P.

1173. *Electrolytic Reduction of Carbon Dioxide and Carbon Monoxide under Pressure.* F. Fischer and O. Prziza. (Ber. Deut. Chem. Gesell. 47. 1. pp. 256-260, Jan. 24, 1914. Dissertation of O. Prziza, Techn. Hochsch. Berlin, 1918. Chem. News, 109. p. 182, March 18, 1914. Abstract.)—The electrolytic reduction of CO₂ at ordinary pressure had been obtained by A. Coehn and H. Jahn, and also by Ehrenfeld. The authors proceed like the former, using their own apparatus designed for the reduction of dissolved oxygen. The CO₂ is passed through solutions of potassium sulphate (also Na- or Li-sulphate); the current yield is better with zinc than with copper kathodes, and still better when copper is coated with zinc, then amalgamated and kept polished; lead kathodes after Tafel also give excellent results, but only when the anode is also lead (not a Pt-wire as in the other cases). Working with a steel bomb at 15 atmos., again with a saturated solution of K₂SO₄, nearly theoretical current yields are also obtained with currents of from 10 to 15 amp./dm.²; the product is formic acid or potassium formate, but the concentration is weak, because the electrolysis has to be stopped after about 10 minutes lest the formic acid anion migrate into the anolyte. The reduction of CO, dissolved under 100 atmos. in alkaline, neutral or acid electrolytes, did not succeed with electrodes of Ni, Fe, Cu, Hg, Pt, Ir, Zn. A little formate was produced in alkaline solutions, but simply by chemical reaction; with Pb kathodes a little methyl alcohol was found, but the current density had to be low, and the yield was very poor. Methane was not observed.

H. B.

1174. *Rapid Determination of Zinc in Minerals.* S. Zublena. (Accad. Sci. Torino, Atti, 8a. pp. 148-161, 1918-1914.)—The author has adapted the method and apparatus of Frary [see Abstracts Nos. 189 and 190 (1908)] to the rapid determination of the zinc-content of minerals. For the details of the operations the original must be consulted.

T. H. P.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS

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GENERAL PHYSICS.

1175. *Automatic Mercury Pump.* Klein. (Journ. de Physique, 4. Ser. 5. pp. 298-298, April, 1914.)—This pump differs from older ones of the same type in that the gases instead of being evacuated directly into the atmosphere are evacuated into a canal system connected with a column of water and, in place of the displacements of the mercury being produced by displacements of the receiver they are produced by the fact that the latter is put in communication alternately and automatically with the atmosphere and with the column of water by the action of a suitable arrangement. Diagrams are given showing the connections of the parts, and the method of working together with the rate at which the gases are removed are dealt with in detail.

A. E. G.

1176. *Calibration Marker for Chemical Apparatus.* K. Wolz. (Zeitschr. Instrumentenk., Beib. 4. p. 87, Feb. 15, 1914.)—An upright frame provided with clamps for holding articles such as litre flasks, etc., is also fitted with sighting tube and marking point. The object is rotated by gearing when the diamond point is adjusted at the proper height.

C. P. B.

1177. *Measuring Apparatus for Spectrograms.* K. Wolz. (Zeitschr. Instrumentenk., Beib. 5. pp. 58-55, March 1, 1914.)—A tape registering train is attached to the screw of the micrometer used for measuring the lines on spectrograms, so that the readings can be directly recorded as made.

C. P. B.

1178. *Slip-curves of an Amsler Planimeter.* A. O. Allen. (Phil. Mag. 27. pp. 648-648, April, 1914.)—When the pivot of an Amsler planimeter has been fixed on the paper, a family of curves may be drawn round it having the property that while the tracing-point moves along any one of them the reading of the wheel is constant, since it slips without rolling. The importance of these curves is that the instrument works least accurately when

the tracer travels nearly along any of them ; consequently, in measuring an area the pole should be so chosen that at all points of the perimeter the tracer may as far as possible cut the slip-curves orthogonally. It is sometimes advisable to divide the area into portions and use a different pole for each portion so as to attain this end. The equation of the slip-curves is here considered, and it appears that a knowledge of the chief geometrical properties of the curve leads to a proof of the principle of the instrument which differs from all those found in the usual text-books. A. W.

1179. Application of the Displacement Interferometer to the Horizontal Pendulum. C. Barus. (Amer. Journ. Sci. 87. pp. 501-518, June, 1914.)—The present paper is the outcome of an endeavour to register the excursions of the horizontal pendulum by displacement interferometry, not so much with a view to recording seismological phenomena as to approach by this means certain other problems, such as the tilting of the earth's surface relatively to the plumb-line, the measurement of the constant of gravitation, etc. If the inclination of the axis of the horizontal pendulum is but a few degrees to the vertical and a large framework is in question, the sensitiveness of the apparatus, when the excursions are read off in terms of light-waves, is remarkable. A full description of the apparatus is given together with a mathematical discussion of the sensitiveness to be expected. In conclusion the author describes some curious results, as yet unexplained, with experiments for measuring the gravitational attraction of two identical brass discs. For constant mass the attraction of nearly contiguous discs should increase roughly as the fourth power of their radius. For discs 20 cm. in diameter, however, the result is an invariable repulsion, several times as large as the estimated gravitational attraction, the equilibrium position being reached gradually in a few minutes. Since the discs are identical and in metallic connection, it would seem as if the absolute electric voltaic contact potential of the metals was being measured, but this effect would be at least 100 times smaller than the observed value. Similarly, the gravitational pressure increment of the film of air between the discs is too small.

H. H. Ho.

1180. Production of High Vacua by Means of Finely-divided Copper. T. R. Merton. (Chem. Soc., Journ. 105. pp. 645-646, March, 1914.)—Finely-divided copper, which may be obtained by reducing a solution of a copper salt and is sold commercially as "precipitated copper," absorbs gases with great readiness, the vapour pressure of the gases thus absorbed being so small that under suitable conditions it may be used for the production of high vacua. A bulb containing a few gm. of the copper is sealed to the vessel to be exhausted, the vessel being then partially exhausted by means of an air-pump and the copper heated to about 250°. When the air-pump is disconnected and the copper allowed to cool, the residual gases are rapidly absorbed. This absorption is not due to chemical combination, since the gases are liberated when the copper is heated. The carbon bands disappear first, then nitrogen, and finally hydrogen, but helium does not appear to be absorbed appreciably. Diminution in the absorbing power of the copper follows (1) the use of an excessively high temperature, (2) repeated use, or (3) prolonged exposure to the mercury-vapour from a mercury pump. Great care is necessary when the copper is being used for the first time, as the occluded gases may sometimes be evolved with such violence that the copper is blown through into the pump ; consequently not more than one-third of

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the bulb should be filled with copper, and a short length of the tube connecting the bulb and the pump should be tightly packed with glass wool.

T. H. P.

1181. *Methods of Finding the Harmonics in a Fourier Series.* J. Beaufort. (Assoc. Ing. É. Liège, Bull. 14. pp. 66-81, Jan., 1914.)—Assuming that the values of y in a periodic curve are known, the author obtains simple series formulæ for determining the amplitudes and phases of the harmonics in the Fourier expansion of y . The formulæ are practically identical with those given by S. P. Thompson [see Abstract No. 1806 (1911)]. The formulæ are proved by the elegant method of projecting the sides of a regular polygon on a straight line.

A. R.

1182. *Note on a Method of Calibrating Shock-testing Apparatus.* G. Charpy and A. Cornu. (Rev. de Métallurgie, 10. pp. 1288-1288, Nov., 1918.)—One of the main difficulties in shock testing is to show the relationship existing between the relative and absolute values and to compare the results obtained with various types of machine. With a view to overcoming these difficulties the authors propose to calibrate impact testers by testing bars in them under a known deformation which is not sufficient to start fracture. Of course it is necessary to ensure absolute homogeneity of the steel from which the bars are cut. Under otherwise similar conditions it has been shown that bars with sharp edges give higher and more erratic results than bars with rounded edges, and it is known that notching gives rise to errors which are not inherent in the machine. It is recommended, therefore, that the graduation test-bars should not be notched and should have their edges rounded off at a very definite radius. Eight series of tests in which the material, size of test-piece, weight and height of fall of tup were varied have shown that the values obtained are practically identical when the conditions of testing are identical. This appears to show conclusively the value of the method in comparing the relative regularity of two machines and in showing the concordance or discordance of their graduations.

F. C. A. H. L.

1183. *Calculation of Thin Oval Tubes under Uniform Pressure.* R. Mayer-Mita. (Zeitschr. Vereines Deutsch. Ing. 58. pp. 649-654, April 25, 1914.)—Gives analytical and geometrical treatment of the problem, and applies results to practice. Critical conditions of instability are discussed.

H. S. R.

1184. *Remarkable Rotational Phenomena of a Centrifugal Apparatus.* K. Uller. (Deutsch. Phys. Gesell., Verh. 16. 5. pp. 249-262, March 15, 1914.)—The experimental work recorded in this paper was carried out with an apparatus designed by König for the quantitative examination of surface effects. This briefly consists of two equal masses m_1 , symmetrically placed and movable upon a transverse arm, and another mass m_2 , movable along the vertical axis. m_2 is connected with both the masses m_1 by inextensible strings, which pass over pulleys situated where the vertical axis and transverse arm cross. In addition the mass m_2 is attached by a thin steel wire to a transverse thread. When this latter is burnt m_2 falls. The apparatus is so arranged that m_2 can fall upon a cork disc attached to the turning wheel, which absorbs the translatory kinetic energy of m_2 . The system is partially rigid. A characteristic feature of the apparatus is that at any instant the angular velocity of all parts of the apparatus is the same as in a perfectly rigid body. If the apparatus be set in rapid rotation the rate only decreases slowly

in consequence of the small frictional and resistance forces. If the thread be burnt which fixes the positions of the masses, the latter do not move immediately, but only when the rotation period exceeds a certain value. It might then be expected that the vertical weight would fall and strike the cork disc beneath, but such is not the case. Instead, the weight comes to rest as though a strong frictional force had been exerted. The new stationary position is maintained for an interval while the rotation velocity slowly decreases, then suddenly the weight moves again; the descending velocity first increases, but then slackens until a second stationary position is arrived at. This alternation of movement and rest is maintained as long as the apparatus dimensions permit, until finally the weight reaches the fixed cork disc. A mathematical discussion is given to explain these remarkable phenomena as a necessary consequence of the dynamics of the apparatus. Numerous curves are given to illustrate the various phases of the problem.

H. H. Ho.

1185. *Variation with Temperature of Internal Friction of Glass.* C. E. Guye and [Mlle.] S. Vassileff. (Archives des Sciences, 87. pp. 214-225, March, and pp. 801-828, April, 1914.)—Describes experimental determinations of the coefficient of internal friction of glass by decrement observations on oscillations performed by a torsion pendulum vibrating in a partial vacuum (25-80 mm. of Hg) and maintained by electrical means at various constant temperatures lying between 18° and 860° C. The assumption that the internal friction is proportional to the velocity and independent of the amplitude gives as the equation of motion, $I \cdot d^2\theta/dt^2 + f \cdot d\theta/dt + c\theta = 0$, where f is the coefficient of internal friction and θ is the amplitude. A short discussion of this equation is given. Experiments were made with ordinary, Jena, and lead glasses, the threads being of drawn glass in each case and examined for anisotropy both before and after the experiments by a polarisation microscope. The pendulum arrangement used was that of Guye and Freedericksz [Abstract No. 221 (1910)], modified slightly to avoid all possibility of shock to the fragile glass threads. The oscillations were recorded photographically. The glass threads were in each case 22.5 cm. long, and between 0.8 and 0.4 mm. in diam. The apparatus was first maintained for 2 hours at the highest temperature employed during the experiment, and observations were then made at a series of different temperatures down to the normal. A second series was made at the same points as before on again raising the temperature to its initial value. In no case did the differences between the two measurements at any one temperature exceed the experimental error. This indicated the absence of temperature hysteresis when the series was performed in the above manner. If, however, the measurements were made in the inverse order with a new thread the heating was found so to affect the glass as to cause a serious diminution in the log. decrement for the descending series of measurements, thus indicating molecular changes in the glass due to initial heating. The decrement did not vary with the amplitude, hence the oscillations obeyed the ordinary equation of motion given above. A change in the moment of inertia, I , however, was found to affect the value of f . The period of oscillation did not vary with the amplitude nor appreciably with the temperature. The decrement varied rapidly with the temperature in every case, rising to a maximum at 200° for ordinary glass, and at 250° for lead glass, then falling to a minimum before rising again still more rapidly. For Jena glass the decrement fell to a minimum at 120° and rose slowly from 120° to 250°, and then more rapidly

to 860° C. From an examination of the photographic records of the oscillations, an approximate determination of the coefficient of damping could be obtained. The coefficients of friction thus deduced were : for Jena and lead glasses, both at 860°, 7·6106 and 18·4028 respectively ; for ordinary glass at 810° C. it was 7·2875. J. W. T. W.

1186. *Air-flow in Wide Tubes.* K. W. F. Kohlrausch. (Ann. d. Physik, 44. 2. pp. 297-320, May 12, 1914.)—Describes two sets of experiments on ordinary air flowing under various pressures through glass tubes 250 cm. long and of sizes varying from 0·88 to 1·79 cm. in radius. In the first set of experiments the fall of pressure along each tube was measured by means of side tubes sealed into it at 5 different parts of its length, and leading to a Töpler pressure gauge. The curves connecting volume of air passing, ϕ , with pressure excess, p , were all found to consist of 2 straight lines meeting at well-defined points, all of which lay close to a straight line parallel to the " p " axis, as required by the Osborne Reynolds formula for the critical point at which gas-flow becomes turbulent. The straight lines forming the lower parts of the curves were in conformity with Poiseuille's law. The other lines when produced all appeared to cut the " ϕ " axis in the same point, ϕ_0 , for any one tube. For different tubes ϕ_0/a is constant, where a is the radius of the tube. Assuming ϕ_0/a to depend only on the coefficient of friction, η , and the density, ρ , then $\phi_0/a = \pi k_1 \eta / \rho$, where k_1 is a constant found to have the value 790 under the conditions of the experiment. Since the second part of the curve is a straight line, $\phi - \phi_0 = k_2 \pi p a^4 / \eta l$, where k_2 is a constant found by these experiments to have the value 0·0816. Hence within the limits covered by these experiments the equation of turbulent flow is $\phi = k_1 \pi \eta a / \rho + k_2 \pi p a^4 / \eta l$. The critical point at which turbulent flow sets in is given by $\phi' = 4\phi_0/3$, and using the values of k_1 and k_2 found above, the critical velocity is found to be $1040\eta/\rho a$.

In the second set of experiments the distribution of pressure over the section of the tube was found, and the corresponding distribution of velocity calculated from the formula $v = \sqrt{2(P - p)/\rho}$, where P is the pressure observed at any point by means of a Pitot tube, and p the pressure measured as in the first set of experiments. Irregularities were found even in the steady-flow portion, but these were probably due to disturbances produced by the Pitot tube. Treating the results obtained for the turbulent flow by a method analogous to that used for the first experiments, v now replacing ϕ , the equation for v is $v\rho a = 2\pi\eta[(a^2 - r^2)/a^2 - 4/K_2] + K_2 p a^2 \rho / \eta l$; here $\kappa = 1040$, $K_2 = k_2 = 0·0816$, and r is the distance of the point of observation from the axis of the tube. J. W. T. W.

1187. *Viscosity of Some Gases and its Temperature Variation at Low Temperatures.* H. Vogel. (Ann. d. Physik, 48. 8. pp. 1235-1272, April 16, 1914. Extract from Inaug. Dissertation, Berlin.)—The author has applied the Coulomb-Maxwell method of swinging for the determination of the viscosity of gases, modifying it so that it could be employed for the determination of the temperature variation of viscosity at low temperatures. As the most probable normal value of the viscosity of air at 278·1° abs., the author finds, from a critical comparison of all previous measurements, $\eta = 1724 \times 10^{-7}$. The author has now determined the viscosity relatively to this value for air, of 20 gases and vapours at 278·1° abs., the viscosity of ten of these being also determined at lower temperatures (down to 21° abs. in the case of H and He). As a result of his measurements, he points out that the above method

is of equal or even of greater value than the ordinary flow method; for the measurement of the temperature variation of viscosity. With regard to the formula of Sutherland, $\eta \sim T^{\frac{3}{2}}/(1 + C/T)$, the author shows that at low temperatures this formula does not agree with the results of experiment, but that C changes with the temperature, and that it tends to a value between 1.2 and 1.5 times the absolute boiling temperature. No satisfactory explanation of this has so far been given. The author points out relationships between the Sutherland constant, C , and the viscosity, and other physical properties, and, by a modification of the Lothar Meyer relationship, he has obtained an approximate formula for the calculation of viscosity from molecular volume, molecular weight, and the boiling temperature, which agrees fairly well with experiment. With the help of this formula the author has recalculated the viscosity of mercury-vapour.

A. F.

1188. *Motion of Gases in Capillary Tubes and between Parallel Planes.* R. Holm. (Ann. d. Physik, 44. 1. pp. 81-96, April 28, 1914.)—In connection with the Siemens and Halske electrical anemometer [see Abstract No. 155 (1914)] the question arises of the law governing the motion of a gas through the space between two parallel plates, the gas entering this space through a circular hole in the centre of one of the plates. A theoretical treatment of the problem is here given, and experiments are described which give results in agreement with the theoretical conclusions. The flow through capillary tubes and through a tube of rectangular cross-section is also treated, the driving pressures in all cases being small, so that Poiseuille's law holds.

A. W.

1189. *Decrement of Small Vibrations in the Flow of a Viscous Fluid.* L. Hopf. (Ann. d. Physik, 44. 1. pp. 1-60, April 28, 1914. From the Aachener Habilitationsschrift.)—Deals mathematically with the critical state in which turbulence is on the point of setting in. Three types of vibration are recognised and are separately treated in detail. The paper contains a number of tables and graphs and should be referred to by those specially interested.

E. H. B.

1190. *Outflow of Explosive Gases.* I. C. Cranz and B. Glatzel. (Ann. d. Physik, 43. 8. pp. 1186-1204, April 16, 1914.)—Describes the electric spark photography, at various instants, of the gases issuing from the muzzle of a gun on firing and sometimes with obstacles introduced in the line of flow. Over a score of photographic reproductions accompany the paper. [See also Abstracts Nos. 8 (1905), 185 (1907), and 145 (1918).]

E. H. B.

1191. *Energy Theorem in Gravitation.* G. Nordström. (Phys. Zeitschr. 15. pp. 875-880, April 15, 1914.)—A mathematical discussion explaining the distinction between the gravitation theories of G. Mie and the author. It is also shown that the contradiction involved in Mie's form of the theory is avoided in that due to the author. [See Abstracts Nos. 854 (1918), 7 and 800 (1914).]

E. H. B.

1192. *Possible Meaning of Quantum Theory.* N. Umow. (Phys. Zeitschr. 15. pp. 880-882, April 15, 1914.)—A mathematical discussion arriving at the following conclusion. Instead of the quantum theory we might retain Maxwell's partition of energy and introduce the following hypothesis: The ether (or the electromagnetic field) is selectively sensitive to the promiscuous

motions of the molecules. This sensitiveness is related to the natural frequency of the molecule and is expressed by the fraction $1/h\nu$, where h is dependent on the properties of the ether and is therefore a universal constant, and ν is the natural frequency of the molecule.

E. H. B.

1193. Nordström's Gravitation Theory. A. Einstein and A. D. Fokker. (Ann. d. Physik, 44. 2. pp. 821-828, May 12, 1914.)—Discusses this theory, and by a different method reaches a result in agreement with it. The authors also point out that the theory under discussion has the advantage of satisfying the theorem of the equivalence of the inertia mass and the gravitation mass.

E. H. B.

1194. Effect of the Gangetic Alluvium on the Plumb-line in Northern India. R. D. Oldham. (Roy. Soc., Proc. Ser. A. 90. pp. 82-41, April 1, 1914.)—This paper deals with the remarkable character of the deflections of the plumb-line at stations near the southern edge of the Himalayas, and examines Burrard's conclusions which, regarding the structure of the range, partly contradict those drawn from geological observations. Briefly the geodetic facts are that along the southern edge of the Himalayas very high northerly deflections, amounting to about 40" of arc, are found, which rapidly decrease in a southerly direction by about 80" in as many miles, after which they become much more gradual. Northerly also there is a decrease, though not so rapid as to the south. Burrard's hypothesis, in explanation of these facts, is the existence of a belt of deficient density, of considerable depth, but of no great width, along the southern edge of the Himalayas. As this rift is on a scale of magnitude far in excess of anything for which there is geological precedent, the author has been led to investigate whether some other explanation was possible more in accordance with geological observations. The geological structure is as follows: Along the southern edge there is a great fault separating the older rocks of the range from the upper tertiary, Siwalik beds, which Medlicott showed to have been formed under conditions similar to those of the recent deposits in the Gangetic depression, and to be the lower, marginal deposits of the same continuous formation, of which the Gangetic alluvium forms the uppermost members. The depth of this formation along the northern margin is certainly great, nowhere less than 10,000 ft., and possibly 80,000 ft. in places. On the southern margin the thickness is small, and the deposit thins out over an old land surface of rock. Between these two limits it is natural to suppose that the depth of the alluvium decreases gradually from north to south, and its mean density has been taken at 2.1, the mean density of the rock forming the sides and floor of the depression being about 2.7. It is the effect of this large bulk of material, having a density of only about seven-ninths of the average density of surface rock, which has been investigated. The method adopted was based on Hayford's system of compartments, the trough being assumed to run east and west, with the deep side on the north, and divided into belts of 10 miles wide, running parallel to the margins, in each of which the depth was assumed to be uniform and equal to the mean depth of the belt. The data obtained are subjected to the necessary corrections, and the general conclusions to be drawn appear twofold: (1) that the local deflections of the plumb-line, produced by underground topography, along the region bordering the southern margin of the Himalayas, are of such magnitude as to make the observations, at stations situated in that region, of small geodetic value, unless allowance is made for the invisible, as well as the visible, topography; and (2) that there is no geodetic justification for the

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assumption of the existence of a deep and narrow rift, filled with material of lesser density than the rock on either side, or for any modification of the deductions, regarding the form of the floor of the Gangetic depression, which have been drawn from geological observation. H. H. Ho.

1195. Principle of Similitude. R. C. Tolman. (Phys. Rev. 8. Ser. 2. pp. 244-255, April, 1914.)—This article presents some considerations which appear to have validity throughout the field of physical science. These conclusions are drawn from a single postulate or new principle which may be stated as follows.

The fundamental entities out of which the physical universe is constructed are of such a nature that from them a miniature universe could be constructed exactly similar in every respect to the present universe. This is called the *principle of similitude*.

This fundamental postulate is a relativity principle, viz. the principle of relativity of size. In the body of the paper it is shown that relations must hold between the changes of lengths, masses, time intervals, energy quantities, etc., in order to construct the miniature world in question. E. H. B.

1196. Essential Foundations for Atomic Models. F. A. Lindemann. (Deutsch. Phys. Gesell., Verh. 16. 6. pp. 281-294, March 30, 1914.)—The following propositions may be considered as experimentally established results to which all atomic models must conform: (1) Atoms are impenetrable to atoms or electrons of speeds less than a value lying between 8×10^6 and 6×10^6 cm./sec., and penetrable to those of higher speeds [Abstracts Nos. 1819 (1918), and 1081 (1914)]. The atomic volume is therefore not completely occupied by atoms. (2) Except for radioactive elements, atoms remain stable for extremely long periods of time. (3) Atoms contain electrons emitting spectra due to very slightly damped electric waves, arising from thermal motions, chemical action, electric resonance, and electronic collisions. These spectra are frequently expressible by empirical formulæ of the type $\nu = A(r_1^{-2} - r_2^{-2})$, when ν is the frequency, A a constant, and the r are integers of which r_1 is the smallest. (4) Even the high-frequency Röntgen spectra are due to undamped vibrations, and the principal lines for atomic masses between 40 and 65 are of the type $\gamma = A\tau^2$, where τ may have values from 19 to 29 [Moseley, Abstract No. 467 (1914)]. (5) A lower limit to the number of free electrons in an atom is given by the deviation of Röntgen rays, and with results agreeing with those of (1). (6) The existence of strongly damped electronic vibrations is shown by the selective photo-effect, and may be due either to vibrations of single atoms or of molecular aggregates. Franck and Hertz's results [Abstract No. 1858 (1918)] suggest the former. The models may be static or kinetic, but in the former case their stability requires an otherwise unknown repulsion which may be dispensed with in the latter, but then electromagnetic radiation must also be excluded. All electrons revolving synchronously must form a single ring [Nicholson, Nature, 92. p. 680, 1914], and for such differences of frequency as between the Röntgen and visible rays this seems hardly possible. All models must fulfil the dimensional conditions previously indicated [Abstract 475 (1914)]. With the same notation, the author considers four cases in detail, with the subsidiary hypotheses necessary, viz., (1) $x = 0$, $\gamma = Ah/mr^2$; (2) $x = 1/2$, $\gamma = A(e^2 N n / m r^3)^{1/2}$; (3) $x = 1$, $\gamma = A N n e^2 / h r$; (4) $x = 2$, $\gamma = A N^2 n^2 e^2 m / h^2$. The latter gives Bohr's formula as applying both to Röntgen and visible rays free from most of his assumptions. G. W. DE T.

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1197. *Recent Physical Discoveries.* J. J. Thomson. (Engineering, 97. pp. 828-825, March 6; 854-855, March 18; 890-891, March 20; 425-427, March 27; 448-444, April 8, and pp. 496-499, April 10, 1914. Discourses delivered before the Royal Inst.)—The first three of these discourses were concerned with the nature of the forces exerted by atoms on each other, and the bearing of this on chemical affinity, while the fourth dealt with metallic conduction. At the outset the importance of the actions exerted between atoms was insisted on, for upon them depend such properties of matter as stiffness and tenacity, those involved in changes of state from solid to liquid, and from liquid to gas; the presence or absence of crystals; but in addition to this there was involved the vast subject of chemistry. The work of the late W. Sutherland was held to be of great value in these connections. Sutherland assigned to each atom a specific attracting power. He held that the variation of this force with distance was the same for all atoms, but that its magnitude depended on a specific constant different for each element. He assumed that each element contained both a positive and a negative charge, but that the two were not quite in the same position. There was thus a residual external field, each atom resembling a little magnet—this arrangement being known as an electric doublet. The application of this view to the subject of valency is worked out and illustrated by figures.

The remaining lectures deal with Röntgen-ray phenomena and with specific heat. E. H. B.

1198. *Gyroscopic Quanta.* R. A. Fessenden. (Science, 89. p. 588, April 10, 1914.)—Points out that it follows from the author's electrostatic-doublet vortex theory of matter, that the energy radiated when a distortional ether wave strikes an atom will be given off in quanta and be proportional to the frequency. The simplest way of seeing this is to take the well-known experiment in which a gyroscope is held in the hand and the body revolved first one way and then the other. On turning the body one way no effect is produced on the gyroscope. On turning the other way the gyroscope resists and is upset, and the axis then points in the opposite direction. It may easily be shown that the amount of work done in upsetting the gyroscope varies directly as the angular velocity of rotation of the body, or, in the case of the atom and ether wave, is directly proportional to the frequency. E. H. B.

1199. *Crushing Tests on Cylindrical Tubes of Lead.* A. Kirsch. (Ferrum, 10. pp. 55-59 and 81-91, 1918. Rev. de Métallurgie, 11. pp. 78-81, Feb., 1914. Extract.)—A long abstract of a paper on the relation between shock crushing tests and the length, external diam., and sectional area of leaden tubes all of equal weight. F. C. A. H. L.

1200. *Critical Loads for Ideal Long Columns.* A. Morley. (Engineering, 97. pp. 566-568, April 24, 1914.)

1201. *Fluid Motions.* Rayleigh. (Engineering, 97. pp. 442-448, April 8, 1914. Nature, 98. pp. 864-865, June 4, 1914. Lecture delivered at the Royal Inst., March 20, 1914.)

1202. *Studies in Brownian Movement.* I. J. H. Shaxby and E. Emrys-Roberts. (Roy. Soc., Proc. Ser. A. 89. pp. 544-554, March 2, 1914.)—Deals with the Brownian motions of bacterial spores. L. H. W.

1203. *On the Relativity of Accelerations in Mechanics.* H. Reissner. (Phys. Zeitschr. 15. pp. 871-875, April 15, 1914.)—Highly mathematical.

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1204. *Minkowski's Mechanics*. B. Weinstein. (Ann. d. Physik, 48, 6. pp. 929-954, March 20, 1914.)—A highly analytical paper dealing with the world-constant, and the mechanics of the system. E. H. B.

1205. *The New Mechanics*. L. T. More. (Science, 89. pp. 595-599, April 24, 1914.)—A semi-popular treatment contrasting the new mechanics, recognising the change of mass with speed, with the classical view in which mass was constant. E. H. B.

1206. *Pulsating Spheres and Gravitation*. A. Korn. (Comptes Rendus, 158. pp. 982-984, March 30, 1914.)—Discusses the conditions under which pulsating spheres immersed in an incompressible fluid would attract or repel. E. H. B.

1207. *Momentum of Progressive Waves*. Rayleigh. (Phil. Mag. 27. pp. 486-440, March, 1914.)—The author here makes some extensions of an approximate mathematical theory developed in an earlier paper [Abstract No. 126 (1906)]. In the first place, the conclusions formerly obtained on the supposition of small disturbances are shown to have a wider validity. He also calculates the momentum of a long progressive wave of mean elevation zero in a uniform canal, and notes the application to periodic waves moving on the surface of deep water. G. W. DE T.

1208. *Further Experiments with Liquid Drops and Globules*. C. R. Darling. (Phys. Soc., Proc. 26. pp. 118-119, Feb., 1914.)—The experiments described are the following:—(1) Communicating drops. (2) Structure of liquid jets. (3) Liquid spheres enclosed in a skin of another liquid. (4) Mixed vapour and liquid drops. (5) Expanding globules. (6) Combination of floating globules. For details the original pages must be consulted. [See Abstracts Nos. 588, 1081 (1911).] L. H. W.

1209. *Tate's Law and the Variation of the Size of Drops with the Frequency, of Fall*. P. Vaillant. (Comptes Rendus, 158. pp. 936-938, March 30, 1914.)—When a drop is detached from a capillary orifice, the perimeter of the section of rupture is considerably less than that of the orifice, and the surface tension calculated according to Tate's law is much too small. It is usually assumed that the weight of the drops is independent of their frequency, whereas actually this weight shows a continual variation, which may exceed a quarter of the total weight. The results of the author's measurements show that the weight of the drop is at first sensibly constant and that it begins to increase as soon as the frequency surpasses 15 per minute. The increase is initially rapid but later proceeds more slowly until at a frequency of 100 the weight passes through a maximum. As the frequency increases continuously, the weight of the drop exhibits three further maxima, each greater than the preceding, and subsequently appears to diminish continuously. It is evident that, when the increased frequency causes the diminution of the volume of the drop to exceed a certain limit, the drop assumes a different form, passage from one form to the other being in general sudden. T. H. P.

1210. *Method for the Determination of the Surface Tension of Amorphous Bodies*. B. Berggren. (Ann. d. Physik, 44. 1. pp. 61-80, April 28, 1914.)—In the case of a thread hanging vertically, surface tension causes a compression, gravity an extension. The velocity of deformation is determined partly by the resultant of these two stresses, and partly by the viscosity of the substance. When the viscosity of deformation is zero, the resultant is
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also zero, and the surface tension can therefore be calculated. With metals, no conclusion regarding the surface tension can be reached, as the metals frequently have a distinctly crystalline structure, which is also modified by "working." In the case of amorphous substances, however, the method indicated above can be applied even when the viscosity is so great as to make determinations by other methods impossible. The author has made such determinations in the case of copal. The accuracy of the method is diminished greatly by elastic after-effects, which give rise to an apparent increase of the surface tension, which is sometimes of considerable amount. In such cases, however, the method yields an upper limit for the surface tension. The experimental results which have been obtained yield values for the surface tension of the same order as those for true liquids. They do not support, therefore, the view that there is an essential difference between the solid and liquid bodies in this respect.

A. F.

1211. *Relations between Pressure, Temperature, and Height of the Troposphere over the European Plain.* W. Köppen and F. Wedemeyer. (Meteorolog. Zeitschr. 81. pp. 1-15, Jan., and pp. 75-86, Feb., 1914.)—Observations by means of registering balloons liberated from Hamburg, Kutschino, Lindenberg, Pawlowsk, Strassburg, and Trappes are used and the methods of correlation are applied to them to obtain correlation coefficients between the quantities indicated. The general plan of the paper is very similar to that of the memoir of W. H. Dines, in connection with the results of British soundings [see Abstract No. 1685 (1912)], and the results from the European observations agree remarkably well with those deduced by Dines from the British observations.

R. C.

1212. *On the Winds in the Lowest Layers of the Atmosphere.* G. Hellmann. (Preuss. Akad. Wiss. Berlin, Ber. 18. pp. 415-487, 1914.)—Three anemographs were exposed at heights of 2, 16, and 82 m. above the ground at a wireless station on the plain to the north-west of Berlin, and the mean increase of wind-velocity with height was determined from their records. In order to obtain a wind record free from the major part of the disturbing influences of the ground, and fairly representative of the velocity of an air-current, it is found sufficient to place the exposed parts of the anemograph at a height of about 16 m. above the ground, which is supposed level and free from trees and other obstructions. The anemograph should be exposed on a support which produces the minimum of disturbance in the air-current, e.g. on an open steel tower, or a flagpole, *not* on a building.

It is known that the diurnal variation of wind velocity at the earth's surface in these latitudes shows a maximum in the afternoon and a minimum about midnight. On mountain-peaks and in the free upper air, however, the variation is reversed, the maximum occurring during the night, and the minimum during the day. The author now shows that with feeble winds the midnight maximum of the upper air extends downwards to within a few metres of the surface of the ground: while, on the other hand, with strong winds the surface régime extends to considerable heights. For the average of all winds the surface variation is contained in a layer which has a thickness of about 50 m. in winter and of about 100 m. in summer. At sea the surface variation as observed on land is absent: indeed, there is little diurnal variation of wind at sea in temperate latitudes, but on the average the maximum occurs at night.

Reasons are given for these results, depending upon the disturbance in the

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general westerly drift of the atmosphere caused by the convection currents which are produced by the daily heating of the earth's surface by the sun.

R. C.

1213. *Observations Made at the Lyons Observatory during the Storm of February 22, 1914.* P. Flajolet. (Comptes Rendus, 158. pp. 744-746, March 9, 1914.)—This storm was the most severe experienced in the Lyons district for 80 years. The mean velocity of the wind was greater than 17 m./sec. from 4h. 40m. to 14h. 40m., and it reached 28 m./sec. from 6h. to 10h. 40m., the max. velocity observed in a gust being 41.6 m./sec. at 8h. 24m. The self-recording instruments show that a rapid fall of the barometer occurred during the whole time that the gale lasted, and was succeeded by a very rapid rise of the barometer. The beginning of the rise in pressure was accompanied by a sharp shower of rain, a rapid diminution in wind velocity, a veer in wind direction, and a sudden drop in temperature.

R. C.

1214. *Micro-seismic Motion.* W. Pechau. (Phys. Zeitschr. 15. pp. 415-416, April 15, 1914.)—The author here communicates some conclusions derived from observations extending over several years which are opposite to those given by Gutenberg [Ibid. 11. p. 1184, 1910]. He distinguishes two kinds of micro-seismic movement, viz. (1) those of 5 to 10 secs. period; (2) those of 40 to 80 secs. period. The former he terms micro-seismic, the latter pulsations. Gutenberg also recognises two kinds of motion, (1) due to local causes such as traffic, storm, surf; (2) due to more universal causes such as the impact of breakers against steep coastlines, wind, and frost. The present author at Jena has not recognised any of Gutenberg's local movements. He ascribes the micro-seismic movements as due to wind action entirely, the period and amplitude being dependent on temperature. Pulsations, on the other hand, are dependent on the air-pressure gradient, and the author only accepts Hecker's conclusion that they are caused by wind action in so far as the latter is connected with the changes in air pressure. The steeper the latter, the larger the amplitude of the pulsations.

H. H. Ho.

1215. *On the Action of Gravity on Gaseous Mixtures, particularly in the Earth's Atmosphere.* G. Gouy. (Comptes Rendus, 158. pp. 664-668, March 9, 1914.)—The result of this mathematical analysis is that if the earth's atmosphere became perfectly quiescent, a separation of oxygen and nitrogen would gradually be partially effected by gravity, the air at the surface would become relatively rich in oxygen and poor in nitrogen, while the higher layers would become richer in nitrogen. Where the pressure is 0.1 of an atmosphere, say at a height of about 15 km., it is found that it would take 988 years for the air to become 1 per cent. poorer in oxygen, and the conclusion is therefore drawn that in the actual atmosphere, which is not quiescent, the action of gravity on the composition of the air is too slow to produce any sensible effect.

R. C.

1216. *Investigation of Deep-sea Deposits.* J. Joly. (Roy. Dublin Soc., Proc. 14. No. 18. pp. 256-267, April, 1914.)—In 1897 the author communicated to the Royal Dublin Society a suggested method of boring into such rocks as might be exposed on the sea-floor. The boring-machine then described involved a motor to drive the drill and an insulated wire from the surface. This machine has been improved while retaining the essential features. Difficulties and expense are involved in transmitting electric power

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from the surface to the bottom at great depths, while to develop power below from storage cells or wound-up springs presents even greater difficulties. Recently it occurred to the author that the pressure of the water prevailing at great depths might itself be utilised to provide the necessary power *in situ*. The principle is simple, being the discharge of the working substance, namely the water, after it has done work in a hydraulic engine, into an empty vessel of sufficient strength to resist the pressure at the bottom. The engine may be of the ordinary reciprocating type with the usual directions of the pressure reversed and acting from without inwards, or the motor may be of the Pelton-wheel form, the wheel being protected from the pressure and water directed from without upon it, the spent water finding its way to the receptacle. A detailed description of a suitable hydraulic engine for boring into the soft sediments and oozes on the ocean-floor is given, illustrated by several plates and diagrams. The mechanism of the drill also receives attention, the various precautions for ensuring efficient working under different conditions being discussed. As it is very desirable to be able to follow the operation of the drill from the boat above, the author proposes to utilise the well-known acoustic properties of water to this end. Above the deck of the sounder a large bell is attached. A hammer is so placed that raised ribs on the drill-tube lift the hammer and again allow it to fall forcibly on the bell four times in a revolution of the drill, a strong spring occasioning the blow. A telephone suspended beneath the surface of the water above enables these strokes of the hammer to be heard. It is easy to arrange such distinctive characters for the succession of hammer-strokes as will enable the position of the drill to be known by the listener above. It is not difficult to reckon up the strokes so that the exhaustion of the batteries can be anticipated and the operation of withdrawing the drill proceeded with while there is still power in the engine, so that the drill is reciprocated back and forth while it is being withdrawn, and its release from the ooze in this way facilitated. The paper concludes with a description of certain modifications of the customary methods of raising sounding-machines in deep water, as it is impossible to operate always under still conditions.

H. H. Ho.

1217. *Occurrence of Ozone in the Upper Atmosphere.* J. N. Pring. (Roy. Soc., Proc. Ser. A. 90. pp. 204-219, May 1, 1914.)—With the aid of an aqueous solution of potassium iodide ozone can be distinguished from nitrogen oxides in very diluted gas mixtures, provided the temperature does not fall below the freezing-point of the reagent -240° C. Hydrogen peroxide would give the same reaction as ozone, but can be distinguished from it by the titanium sulphate test. The action of ultra-violet light on air is studied in a bulb, immediately surrounding the quartz tube of the mercury lamp, so that the rays pass through the quartz walls directly into the air; the whole apparatus is immersed in water. The arc is started with the aid of an induction coil, after joining the lamp terminals to a source of current at 100 or 200 volts; the secondary of the coil is also connected with one of these terminals and, further, with a wire wrapped round the annular jacket of the lamp; the coil is worked until a glow discharge, followed by the arc, is seen in the lamp. In this apparatus no nitrogen oxides nor hydrogen peroxides were produced; the ozone production decreased when the gas pressure was reduced, from 0.01 per cent. at 760 mm. to 0.0014 per cent. at 80 mm. With the absorbing vessels of Hayhurst and the author, atmospheric measurements were conducted in the Alps at altitudes between 2000 and 8500 m. Free balloon measurements were made from Manchester. In the Alps the mean quantity

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of ozone found in one volume of air was 2.5×10^{-4} at 2100 m., and 4.7×10^{-4} at 8580 m.; the amount did not increase much at higher altitudes up to 20 km.; the ozone contents fluctuated; nitrogen oxide and hydrogen peroxide were not observed in the upper atmosphere. The amount of ozone stated sufficed, as laboratory experiments indicated, to impart a blue colour to the gas; thus ozone would contribute to the blue colour of the sky.

H. B.

1218. *Cooling of the Earth.* A. Véronnet. (Comptes Rendus, 158. pp. 588-541, Feb. 28, 1914.)—An estimate is made of the probable rate of cooling of the earth, taking various assumptions as to the composition of the surface and interior materials.

C. P. B.

1219. *Zodiacal Light.* C. Abbe. (Mount Weather Observatory, Bull. 6. 8. pp. 78-80, 1914.)—The question is raised whether the cosmical dust which possibly gives rise to the zodiacal light is closely connected with the upper regions of the earth's atmosphere.

C. P. B.

1220. *Zodiacal Light.* M. Hall. (Mount Weather Observatory, Bull. 6. 8. pp. 61-67, 1914.)—Observations of the position, breadth, and illumination of the zodiacal light were made from Dec., 1911, to Nov., 1912, in the course of an investigation to ascertain whether the phenomenon be in the ecliptic plane or in the invariable plane of the solar system. Tables are given showing the geocentric longitudes and latitudes of points on the central axis of the band, and of its breadth at points whose geocentric longitude are known. The author concludes that the zodiacal light is due to particles of cosmic dust remaining after the formation of the planets of the solar system.

C. P. B.

1221. *Diurnal Variation of Refractions.* R. H. Tucker. (Lick Observatory, Bull. No. 281.)—Observations of a fundamental character for the investigation of diurnal variations of refraction were commenced at Mount Hamilton, California, in 1905, and the results of the first year's work are discussed in the present paper. The plan included two programmes, each of 4 hours' duration and differing by 12 hours of right ascension. An indication is shown of a difference in the effect of refraction between day and night observations, the amount of which does not appear to depend upon either the barometric pressure or the temperature. From a detailed discussion of the spectral types of the stars employed it is also concluded that the difference has not any definite relation to spectral type or colour.

C. P. B.

1222. *Distribution of Sun-spots in Heliographic Latitude.* E. W. Maunder. (Roy. Astronom. Soc., M.N. 74. pp. 112-116, Dec., 1918.)—Curves are given showing the distribution of sun-spots in latitude for the period 1874-1918, in continuation of the results communicated in previous papers. Examination of the diagram shows how clearly Spoerer's law is followed, there being but a single movement in either hemisphere, the trend of which is downward, from one minimum to the next minimum. Curves of sun-spot area are also given for the same period, to show the intimate agreement in the periodicity both in latitude and area. The only period represented with certainty is that of 11.1 years. Both hemispheres have the same period, but differ slightly in phase. Reference is made to the fictitious periodicities which may be introduced by mere statistical analysis of the data.

C. P. B.

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1223. General Displacement of Lines in Solar Spectrum. J. EVERSHED. (Kodaikanal Observatory, Bull. No. 86. *Nature*, 98. p. 69, March 19, 1914. Abstract.)—From a series of the arc and solar spectra of iron it is concluded that the general displacement of lines to the red in the solar spectrum relative to the terrestrial spectrum cannot be accepted as due to pressures in the solar atmosphere. The lines which show most shift in the laboratory under pressure are least affected in the sun. It is proposed to regard the phenomenon as due to a movement of descent with a negative acceleration. C. P. B.

1224. Contraction and Heat of the Sun. A. VÉRONNET. (*Comptes Rendus*, 158. pp. 898-400, Feb. 9, 1914.)—A series of calculations are presented to determine the relations between the rate of contraction, heat radiated, and duration in certain state, on various assumptions as to the solar constitution, liquid or gaseous. C. P. B.

1225. Capture of Comets by Jupiter. FESSENKOFF. (*Comptes Rendus*, 158. pp. 541-544, Feb. 28, 1914.)—An analysis is made of the conditions necessary for the probable disturbance of a cometary orbit by Jupiter to be sufficient to cause the comet to become a member of the solar system. The probability appears to be chiefly dependent on the inclination of the cometary orbit to the ecliptic. C. P. B.

1226. Spectrum of Comet Brooks (1911c). W. H. WRIGHT. (Lick Observatory, Bull. No. 209.)—Photographic records of the spectrum of Comet Brooks were obtained with slit spectrographs and a prismatic camera without slit, during Sept. and Oct., 1911. An interesting feature is that the tail bands were quite faint at first, and later became much more prominent relative to the intensity of the nucleus. Very marked changes are described which occurred in the relative intensities of some of the bright lines in the spectrum of the head and nucleus. Tables are given showing the lines measured from $\lambda 3864$ to $\lambda 6680$, with reference to their probable coincidence with the CO spectrum as published by Fowler. A series of excellent reproductions of the spectra is included with the paper. C. P. B.

1227. Photographic Observations of Comet Brooks (1911c). C. C. KIESS. (Lick Observatory, Bull. No. 289.)—Lists are given of the details of 29 photographs of Brooks' comet of 1911, taken at the Lick Observatory, with notes calling attention to the chief points of interest. Seven of the plates are reproduced in the paper, showing the changes in the tail and head envelopes. C. P. B.

1228. Magnesium Lines in Stellar Spectra. F. E. BAXANDALL. (Cambridge Phil. Soc., Proc. 17. No. 4. pp. 828-825, Jan. 80, 1914.)—In a recent paper by Fowler [Abstract No. 1948 (1918)] four magnesium spark lines are recorded which do not belong to the series considered. These four lines occur in a part of the spectrum available for comparison with stellar spectra, the series lines, with the exception of $\lambda 4481.3$, being outside the region usually obtained in stellar spectrum photographs. Photographs of the spectra of α -Cygni and α -Canis Majoris obtained at South Kensington show lines whose wave-lengths are $\lambda 4384.7$, $\lambda 4428.4$, $\lambda 4484.8$. Fowler's wave-lengths for the Mg lines are $\lambda 4384.86$, $\lambda 4428.20$, $\lambda 4484.20$. Another stellar line $\lambda 4391.0$ is probably the proto-titanium line $\lambda 4391.19$, since all the other prominent enhanced lines of Ti are represented in these stellar spectra, but

the Mg line given by Fowler at $\lambda 4890.80$ may enter into the composition of the line $\lambda 4891.0$. Comparison of the line $\lambda 4884.7$ with two neighbouring lines whose wave-lengths are accurately known leads to the conclusion that either the laboratory line and the stellar line are not identical, or the wave-length given by Fowler is from 0.1 to 0.2 \AA. too high. The 4481 line of Mg, which is a very strong line in Fowler's spectrum giving the Mg lines under discussion, is, in stellar spectra, about at its maximum in such stars as α -Cygni and α -Canis Majoris, in which these other Mg lines appear to exist. A. W.

1229. Spectrum of η Carinae. J. H. Moore and R. F. Sanford. (Lick Observatory, Bull. No. 252. pp. 55-61, 1914.)—The spectrum of this star has recently been photographed at the Lick Observatory with a prism spectrograph giving a linear dispersion of 86 \AA. to the mm. at H γ . The spectrum is essentially one consisting of bright lines, and shows no dark lines such as have been described by former investigators. Many of the constituent lines have been identified with the enhanced lines of Fe, Ti, and Cr, but a considerable number of fairly strong lines in the spectrum are still unidentified. The lines of helium, the nebular lines, and magnesium $\lambda 4481$ are absent, but a comparison of the spectrum with that of Novæ in the early stages of their history indicates a close connection between the two spectra. C. P. B.

1230. Cluster Variable RR. Lyræ. C. C. Kiess. (Lick Observatory, Bull. No. 282.)—From a series of photometric observations made at the Lick Observatory it is concluded that the star RR. Lyræ belongs to the class of Cluster variables. Comparison of the times of maximum indicated a period of 0.566826 day. Radial velocity observations show the star to be a spectroscopic binary, with period equal to that given by the light-changes. C. P. B.

1231. Correlation of Stellar Spectra, Colours, and Parallaxes. P. Nashen. (Astronom. Nachr. No. 4722. Nature, 98. p. 145, April 9, 1914. Abstract.)—A list of 246 stars is given, showing their parallax, spectrum type, and colour. The analysis of these data leads to the conclusion that the white stars decrease with increasing parallaxes, while the red stars increase under similar conditions. C. P. B.

1232. Orbit of δ Cephei. J. H. Moore. (Lick Observatory, Bull. No. 284.)—Thirty-eight spectrograms of this interesting binary were obtained at the Lick Observatory during the latter part of 1907, comparisons being made with the spectrum of α Ursæ Minoris, which is very similar. Curves are given showing the variations of radial velocity as measured, and their very decided relation to the variations in brightness of the star. C. P. B.

1233. Distribution of Nebulae. E. A. Fath. (Astronom. Journ. Nos. 658-9. Observatory, No 472. pp. 185-186, March, 1914.)—A discussion is given of a systematic search for nebulae in Kapteyn's "Selected Areas," plates having been taken covering 189 out of the 206 regions comprising the scheme. The exposures were made with the 60-in. reflector at Mount Wilson, and each lasted one hour. A number of new nebulae are noted, and an interesting series of conclusions as to the general distribution are given. The concentration of nebulae near the north galactic pole is very noticeable, but there are great variations in the density of distribution. There is a complete absence of these nebulae where the Milky Way crosses the sky. C. P. B.

LIGHT.

1234. *A Photographic Prismatic Astrolabe.* R. Baillaud. (Comptes Rendus, 158. pp. 1249-1252, May 4, 1914.)—The author discusses certain errors of the instrument, and suggests that they may best be avoided by employing photography. Let a photographic plate be placed nearly in, and parallel to, the focal plane of the instrument. Then the direct and reflected images of a star will each trace on the plate a trail which may be interrupted at definite intervals. In this way points $a_1a_2a_3, \dots, b_1b_2b_3, \dots$, corresponding to the same instants, can be obtained on the two trajectories. Assuming the prism to be correctly adjusted, and the operation to take place near coincidence, the horizontal velocities of the images are the same, and their vertical velocities are equal and opposite in sign. Hence, the bisector of the angle between the two trails defines the horizontal direction on the plate. The line connecting the two images at the moment when, what is for convenience called "coincidence" would occur, is the horizontal line passing through the middle points of the lines joining corresponding points a_1b_1, a_2b_2, \dots of the two trails, and can therefore be determined. The time of coincidence can be deduced from measurement of the intervals $a_1a_2, \dots, b_1b_2, \dots$, and knowledge of the time the image takes to traverse them. The problem is simplified when the two trajectories are nearly vertical in the field of view. If the plate is put in the same position at each observation, any slight error in focusing need not be taken into account. In any case such error may be made extremely small by employing Hartmann's, or other, method of finding the focus.

A. E.

1235. *New Arrangement of Mirrors for Lighthouses, etc.* E. Cannevel. (Comptes Rendus, 158. pp. 984-986, March 30, 1914.)—This arrangement consists of a stepped mirror, which is composed of a number of parabolic and annular elements, and is combined with a spherical mirror. The different paraboloidal fragments all have the same focus, and part of each projects rays directly to infinity, whilst the other part, masked by the succeeding step, also sends the rays to infinity, but by way of the ring connecting them, the angle of incidence making the rays pass through the spherical mirror placed at the bottom of the truncated, circular stepped mirror. This arrangement of mirrors increases considerably the reflecting surface and, since the images projected by the rings are not exactly superposed, it may be used with filament lamps. Difficulty having been experienced in making the mirror in metal, use is made of glass silvered electrically by cathodic projection under a bell, which, after being evacuated, was filled with hydrogen under pressure in order to prevent oxidation of the metal.

T. H. P.

1236. *Prism with Curved Faces.* C. Féry. (Journ. de Physique, 4. Ser. 5. pp. 261-265, April, 1914.)—The author has previously shown how a prism with curved faces, one of the curved faces being made reflecting, can be used in the construction of a spectrograph [see Abstract No. 586 (1910)]. It is here shown how such prisms may be employed generally to give a pure spectrum, even though the incident beam is not parallel. If the beam is divergent a concave face is used for the incident light, and a convex face

when a convergent beam is employed. The diacoustic of such a prism is situated on a circle, whatever the dispersive properties of the material, and this circle contains the centres of the curved faces of the prism. A description is given of the way in which prisms with curved faces may be used (i) for transforming a convergent beam into a spectral image, *e.g.* the image of a star furnished by an astronomical objective; (ii) for the study of infra-red spectra; and (iii) for the study of ultra-violet spectra. For particulars of these the original paper should be consulted. A. W.

1237. Polarisation Spectrophotometer with Brace Prism. H. B. Lemon. (*Astrophys. Journ.* 89. pp. 204-212, April, 1914.)—A description of a modified form of the Brace instrument containing a simple polarising arrangement in one of the collimators. The sensibility of the instrument approaches that of the eye to differences in intensity, and while it preserves the great economy of light furnished by the Brace prism and the excellence of elimination of the dividing line, there is complete freedom from the cumbersome calibrations necessary with the older form of the instrument. C. S. G.

1238. Diffraction of Light by Spheres of Small Relative Index. Rayleigh. (*Roy. Soc., Proc. Ser. A.* 90. pp. 219-225, May 1, 1914.)—Keen and Porter have described curious observations on the intensity and colour of light transmitted through small particles of precipitated sulphur about the size of the wave-length of the light [see Abstract No. 645 (1914)]. The present paper then treats the matter mathematically upon certain assumptions, but does not entirely clear up the matter as to the augmentation of transparency at a certain stage as observed by Keen and Porter. E. H. B.

1239. Photometry of the Superficial Resonance of Sodium-vapour. L. Dunoyer and R. W. Wood. (*Comptes Rendus*, 158. pp. 1068-1071, April 14, 1914. *Le Radium*, 2. pp. 111-118, April, 1914.)—This paper deals with measurements that have been made of the way in which the intensity of the surface resonance of sodium vapour varies with the intensity of the salt flame used for excitation. The measurements have revealed the maximum luminescence of the molecular resonators, and, further, have given approximately the width of the resonance D-lines. The experimental arrangement for producing the surface resonance was the same as that used in the preliminary investigation [Abstract No. 859 (1914)]. The photometric method consisted in comparing the intensity of the surface resonance with that of a white, matt layer of magnesia deposited on the wall of the bulb containing the sodium-vapour, this layer receiving the same illumination as the vapour showing surface resonance. All measurements were taken at a temperature of about 880° C. The observations confirm the fact previously noted by Wood for mercury-vapour and by Dunoyer for sodium-vapour, that the resonance lines should be much finer than the exciting lines [Abstract No. 801 (1918)]. Making use of some measurements of Fabry and Buisson it is calculated that the width of the resonance lines in the conditions dealt with is of the order of 0.08 Å. unit. A. W.

1240. Photometry of the Superficial Resonance of Sodium-vapour. L. Dunoyer and R. W. Wood. (*Comptes Rendus*, 158. pp. 1265-1267, May 4, 1914. *Le Radium*, 2. pp. 119-128, April, 1914. *Phil. Mag.* 27. pp. 1026-1085, June, 1914.)—In a previous paper [see preceding Abstract] a calculation was made of the width of the lines emitted by the surface
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resonance of sodium vapour under the excitation of the sodium D-light. The calculation was based on the incorrect formula $y = Ce^{-kx}$ for the partition of energy in a spectral line, x being the distance, in wave-lengths, from the centre of the line to the point where the intensity is y . The correct formula, due to Fabry and Buisson [Abstract No. 1190 (1912)], is $y = Ce^{-kx^2}$. Applying this formula to the results obtained, and using some of the results of Fabry and Buisson, it is found that the resonance lines are nearly four times narrower than the exciting lines. Assuming the value 0.04 \AA. unit for the half-width of the D-lines emitted by a flame very poor in sodium, the width of the resonance lines becomes 0.0216 \AA. unit , instead of 0.082 \AA. unit as previously found. Thus we have here spectral lines a little narrower than the spectrometric standards furnished by the iron arc, though they are still about three times the width of the finest lines, such as the red line of cadmium.

A. W.

1241. *Interferometric Wave-length Measurements in the Infra-red.* A. Ignatieff. (Ann. d. Physik, 48. 8. pp. 1117–1186, April 16, 1914.)—Wave-length measurements by the interference method have so far only been attempted in the infra-red up to 8824 \AA. The paper describes in very full detail arrangements for extending such measurements to lower regions and for examining the purity of infra-red lines. In particular the He lines 10880 and 20581 and the Cd line 10894 \AA. are investigated, and it is found that of these lines the $10,880 \text{ \AA.}$ line alone is double. The wave-length of the auxiliary line is smaller than that of the chief component and for the perpendicular and end-on positions of the capillary tube the intensities are respectively $1:5$ and $8:4$.

C. S. G.

1242. *Measurement of Standard Wave-lengths in the Infra-red.* H. Werner. (Ann. d. Physik, 44. 2. pp. 289–296, May 12, 1914. Extract of Dissertation, Tübingen.)—The lines of the vacuum arc spectrum of barium between 5971 and 7911 \AA. are measured in international units, using as standard the Fe line 6494.998 \AA. The arrangement employed consists in first forming Haidinger rings by passing the rays through a Hilger étalon. By means of a plane and a concave mirror the rays are then passed through the slit, analysed by a grating and photographed. Corrections are applied to the measurements for the difference in the focal lengths of the grating and the concave mirror, temperature-changes and the change of phase at the reflecting surfaces. An accuracy of about 0.002 \AA. is obtained. The lines at 6141 and 6496 \AA. do not appear to possess satellites, as previously supposed, but instead exhibit slight reversal at their centres. On the other hand, the lines at 7195 and 7892 are undoubtedly composite.

C. S. G.

1243. *Series in the Spectra of Indium and Gallium.* F. Paschen and K. Meissner. (Ann. d. Physik, 48. 8. pp. 1228–1226, April 16, 1914.)—A continuation of similar work on aluminium and thallium [see Abstract No. 1875 (1909)]. The measurements were made photographically and visually, both grating and prism apparatus being employed. Four principal series lines of indium are observed between $\lambda\lambda 6900$ and 4878 \AA. , and a formula is developed to which they are conformable. In the case of gallium, lines of the principal series and both the first and second auxiliary series are measured and the constants of the series formulae are estimated from these measurements.

C. S. G.

1244. *Extension of the Spectrum in the Extreme Ultra-violet.* T. Lyman. (Nature, 98. p. 241, May 7, 1914.)—Schumann's researches led him to extend the spectrum to about $\lambda 1250$. Lyman, using a concave grating, further extended it to $\lambda 1080$, and has now succeeded in photographing the spectrum of hydrogen to $\lambda 905$. It is characteristic of the region investigated by Schumann between $\lambda 1850$ and $\lambda 1250$ that, while hydrogen yields a rich secondary spectrum, with the possible exception of one line no radiation has been discovered belonging to the primary spectrum. On the other hand, in the new region between the limit set by fluorite and $\lambda 905$, a disruptive discharge in hydrogen produces a primary spectrum of great interest made up of perhaps a dozen lines. These lines are always accompanied in pure hydrogen by members of the secondary spectrum, but they may be obtained alone if helium containing a trace of hydrogen is employed. Results obtained from vacuum tubes when a strong disruptive discharge is used must always be interpreted with caution, since the material torn from the tube itself sometimes furnishes impurities. In the present case, it will be some time before the effect of such impurities can be estimated. However, it may be stated with some degree of certainty that the diffuse series predicted in this region by Ritz has been discovered. The first member at $\lambda 1216$ is found to be greatly intensified by the disruptive discharge, and the next line at $\lambda 1026$ appears also, though very faintly. This diffuse series bears a simple relation to Balmer's formula. Following the same kind of argument, a sharp series corresponding to the Pickering series might be expected. The new region appears to yield two lines belonging to such a relation at the positions demanded by calculation. A. W.

1245. *Theory of the Electric Dispersion of the Hydrogen Lines.* E. Gehrcke. (Deutsch. Phys. Gesell., Verh. 16. 9. pp. 481-485, May 15, 1914.)—The theory of the electric dispersion of the hydrogen lines has been considered by Warburg and by Garbasso [Abstracts Nos. 460, 667 (1914)], also by Gehrcke and Bohr. The formulæ deduced for the magnitude of the separation are respectively $\delta\lambda = \pm h p^2 \lambda^3 F / 4\pi^2 c m e \dots (1)$, $\delta\lambda = \pm 8h(p^2 - q^2)\lambda^2 F / 4\pi^2 c m e \dots (2)$, $\delta\lambda = \pm h(p^2 - q^2)\lambda^2 F / 2\pi^2 c m e \dots (3)$, $\delta\lambda = \pm 8h(p^2 - q^2)\lambda^2 F / 8\pi^2 c m e \dots (4)$. In the present paper these four formulæ are discussed. The formulæ are similar in many respects, but do not give the same results for the dependence of $\delta\lambda$ on the wave-length. Taking the formula $\nu = \nu_0[1/q^2 - 1/p^2]$ for the Balmer series, it follows that $p^2 - q^2 = \lambda_\infty \cdot q^2 p^2 / \lambda$, where λ_∞ denotes the wave-length of the end of the series. Taking $q = 2$, each of the formulæ (2) to (4) gives an expression of the form $\delta\lambda = \pm \text{const. } p^2 \lambda \dots (5)$, while formula (1) gives $\delta\lambda = \pm \text{const. } p^2 \lambda^2 \dots (6)$. The results of Wilsar [Gesell. Wiss. Göttingen, Ber., 1914], and of Stark and Kirschbaum [Abstract No. 1071 (1914)], though showing slight discrepancies, are represented very much better by a formula of type (5) than by one of type (6). A discussion of the experimental results shows that they can be generally explained by the author's model atom, as regards the magnitude of the separation of the inner and outer components and their dependence on the field strength and series number, as well as the polarisation and intensity ratios of the components and the asymmetry of the separation. A. W.

1246. *Atomic Structure and High-frequency Spectra.* J. W. Nicholson. (Phil. Mag. 27. pp. 541-564, April, 1914.)—Moseley's remarkable experimental results [Abstract No. 467 (1914)] give a new order of simplicity to the deter-

mination of wave-lengths of the characteristic Röntgen radiation from metals. They indicate a definite law which appears to connect successive elements in the Periodic Table; and the author suggests that "they supply perhaps the most hopeful way of obtaining a more intimate knowledge of the inner structure of the atom, and of the essential relations between the various elements." Moseley interprets his results in terms of Bohr's theory and the author shows that the interpretation is open to criticism in some of its details. In the first place he arrives at the conclusions from general mathematical considerations which he promises to amplify in a further paper, and from the detailed examination of the configuration suggested by Bohr for the lithium atom, that an atomic Saturnian system, consisting of concentric coplanar rings of electrons rotating about a central positive nucleus, is a practical impossibility even according to Bohr's theory, as in order to retain the coplanar rings which he assumes we should have to depart from dynamics even more completely than he has, and admit the possibility of an uncompensated force of electrostatic type producing no corresponding acceleration, or else change the laws of force between electrons altogether, while preserving them as between electron and nucleus. According to ordinary electrodynamics coplanar rings are mathematically impossible; and we cannot retain Bohr's theory of the more complex atoms, and van den Broek's hypothesis in its present form simultaneously. According to this hypothesis, the atomic number of an element, *i.e.* the electron-equivalent of the positive nucleus of the atom, corresponds exactly to its position in the Table as we know it. There is no conflict in the case of H and He, but for the more complex atoms, if Bohr's theory is to be retained, the hypothesis must be modified by allowing the atomic number to be different from the position in the Periodic Table. Substituting non-coplanar for coplanar rings, and so modifying van den Broek's hypothesis, Bohr's theory of the more complex atoms can apparently continue to represent the facts for at least some distance in its development. Moseley's interpretation of his results is vitiated by an error, the omission of the factor n from the formula, in the usual notation, derived from Bohr's theory giving the frequency emitted between two stationary states by a ring in which every electron has angular momentum $Rrh_2\pi$, angular velocity ω , and radius a , viz.—

$$\gamma = 2\pi^2 mc^4 / h^3 \cdot n(N - S_n/4)^2 (r_1^{-2} - r_2^{-2}).$$

Therefore, as far as yet discussed, Moseley's observations have shown no relations to Bohr's theory, and the author considers that what he has really shown is that the frequencies of the principal Röntgen rays of the elements are proportional to the squares of natural numbers, a remarkable result which must lead to further knowledge of atomic structure.

G. W. DE T.

1247. Bohr's Theory and Hydrogen and Helium Spectra. J. W. Nicholson. (Roy. Astronom. Soc., M.N. 74. pp. 425–442, March, 1914.)—According to Bohr's theory, the line $\lambda 4686$ of nebulae and Wolf-Rayet stars, together with Pickering's series, hitherto ascribed to H, and the recent series of Fowler, are due to He with a single positive charge arising during the formation of a charged atom from a single positive nucleus and an approaching electron. If these lines therefore are, as in the average Wolf-Rayet star, much stronger than ordinary He lines, the majority of the He atoms should apparently be repeatedly in a state of being deprived of all their electrons. Hence, either electrons are scarce in the nebulae and such stars, and they must have

considerable positive charges, or electrical agencies are at work strong enough to separate the atoms completely into their positive and negative components. Either supposition would be of fundamental import to the nature of these bodies, and of the Novæ. Some strong lines in the Wolf-Rayet stars are, moreover, attributed to lithium, and the same considerations apply, for there is no other evidence of its presence. The application of Bohr's theory to H can give no information on these points, H so easily losing its electrons, but it suggests an explanation of the fact that few Balmer lines are obtainable in the laboratory, while over thirty are visible in the chromosphere spectrum, because Bohr suggests that the tenuous solar atmosphere allows the atoms to expand to a large multiple of their normal size. This is contrary to evidence mainly derived from spectrum line displacements tending to show presence of regions of considerable pressure in the chromosphere, but Evershed, in a recent Bulletin of the Kodaikanal Observatory, has given serious reasons for doubting the existence of such pressures. J. J. Thomson's photography of *positive rays* gives continuous evidence of He-atoms with one positive charge, but only rarely with two charges. The latter, according to Rutherford's theory, as well as Bohr's, are simply α -particles. It appears then, difficult to remove two electrons from the He atom. Yet this must have been done, according to Bohr's theory, in Fowler's tubes showing the line $\lambda 4686$ strongly. And Evans has confirmed his results [Abstract No. 225 (1914)]. If such tubes were examined by Thomson's method a decisive criterion of Bohr's theory would be obtained, confirming it if positive ions, with an "electric atomic weight" equal to 2 were found more strongly than usual, and disproving it if the result were negative.

The Balmer series does not give the main part of the ordinary terrestrial spectrum of H, the so-called secondary spectrum being at last admitted to be a true H-spectrum, and is attributed to molecules, perhaps H_2 , as shown to exist by J. J. Thomson, as well as H_2 . Part of this secondary spectrum shows Zeeman-effect, part not, and the former is generally, if not entirely, absent from astronomical spectra. Probably this part is due to negatively charged H-atoms largely present in vacuum tubes. If so, the consequent absence of negatively charged H-atoms from astronomical spectra is of much import. This would lead to the conclusion, *e.g.* that the chromosphere, in which H is abundant, must be positively charged, for the radiation is strong, involving, on any theory of spectra, a continuous interchange of electrons, so that if neutral, many negatively charged H-atoms would always be present. This is noteworthy in view of the fact, proved in former papers, that the corona has a large negative charge. For it would seem that the corona consists of negatively charged atoms shot off, perhaps by a process of radioactivity, from the chromospheric atom, which would leave a positive charge in the chromosphere.

The author shows by a detailed mathematical investigation that the secondary and H spectrum cannot be accounted for on Bohr's theory as (1) due to the atom, charged or neutral; (2) the spectrum of the molecules, when neutral; (3) arising during the transition from the molecular to the atomic state; and that, in fact, Bohr's theory cannot explain any portion of the H-spectrum except the Balmer and Ritz series, and perhaps a Schumann series. Further, the theory gives rise to nothing analogous to the ordinary He spectrum, for, on investigation of the simplest stationary states, the resulting spectrum is quite unknown. And the author states that a more complete investigation of all the stationary states has been equally unsuccessful.

In all the cases examined the expressions for the frequencies of the emitted
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radiation assume the form $\gamma = A(r_1^{-2} - r_2^{-2})$, where the constant A varies considerably, and though always containing, as a factor, the Rydberg constant, which Bohr identifies with $2\pi^2me^4/h^3$, the other factors have no simple general form. In fact, Rydberg's constant, as a universal constant of spectra, is not preserved, and Bohr's theory can proceed only by the further deviations from ordinary dynamics indicated in the preceding abstract. [See also Abstract No. 1040 (1914).]

G. W. DE T.

1248. *Arc and Spark Spectra of Strontium*. H. Hampe. (Zeitschr. wiss. Phot. 18. pp. 848-868, April, 1914.)—Describes measurements of the wavelengths of the lines of the arc and spark spectra of strontium. The Rowland grating of Bonn University, 6.84 in. radius and 20,000 lines to the inch, was employed. The results, in international units to three decimal places, are tabulated, and some lines are arranged in series. Three triplet series are noted. The members of the first subordinate series of triplets possess satellites. The first line of the triplets has two, and the second one satellite; the third line is simple. Numbering these lines and satellites 1-6, it is found that 1 and 4, as well as 2 and 5 have the same frequency-difference 894.2; 4 and 6 have a smaller frequency-difference 186.8. Only two triplets of the second subordinate series are given. A single triplet is given which does not appear to belong to the subordinate series, but has the same frequency-differences, 894.2 and 186.8. Two pairs of lines are given with the frequency-difference 894.2. Three pairs of lines show the double difference 801.4. Other triplet series are given characterised by the smaller frequency-differences 100.5 and 59.7.

A. W.

1249. *High-frequency Spectra of the Elements*. II. H. G. J. Moseley. (Phil. Mag. 27. pp. 708-718, April, 1914.)—Part I. of this paper dealt with a method of photographing X-ray spectra, and included the spectra of a dozen elements [Abstract No. 467 (1914)]. More than thirty other elements have now been investigated, and simple laws have been found which govern the results, and make it possible to predict with confidence the position of the principal lines in the spectrum of any element from Al to Au. The general experimental method was the same as in the earlier work, the same crystal of potassium ferrocyanide being used as analyser throughout. Since the radiations of long wave-length cannot penetrate an Al window or more than a few cm. of air, the photographs in this case had to be taken inside an exhausted spectrometer, a description of which is given. A window of goldbeater's skin allowed the radiation to enter the spectrometer, this substance being extremely transparent to X-rays and being capable, if left undisturbed, of withstanding the pressure of the atmosphere. The results of the investigation may be summarised as follows:—(1) Every element from aluminium to gold is characterised by an integer N which determines its X-ray spectrum. Every detail in the spectrum of an element can therefore be predicted from the spectra of its neighbours. (2) This integer N , the atomic number of the element, is identified with the number of positive units of electricity contained in the atomic nucleus. (3) The atomic numbers for all elements from Al to Au have been tabulated on the assumption that N for Al is 13. (4) The order of the atomic numbers is the same as that of the atomic weights, except where the latter disagrees with the order of the chemical properties. (5) Known elements correspond with all the numbers between 18 and 79 except three. There are here three possible elements still undiscovered. (6) The frequency of any line in the X-ray spectrum is approximately proportional to $A(N - b)^2$, where A and b are constants.

A. W.

1250. Ratio of the Intensities of the D-Lines of Sodium. R. W. Wood. (Phys. Zeitschr. 15. pp. 882-888, April 15, 1914.)—Many measurements of the intensity ratio of the Na D-lines have been made. Brotherus has shown [Abstract No. 1858 (1912)] that the ratio varies with the quantity of sodium present in the flame. The highest value obtained by him was $D_2/D_1 = 1.5$ and the lowest 1.3. Using a flame very poor in sodium, Wood now finds that the ratio may be as much as 8 or more. A Méker burner was used, coloured only by the sodium present in the air of the room, the air having previously passed through a second Méker burner, on whose grid was placed a stick of NaCl impregnated with sodium. A large constant-deviation spectrograph was employed and five exposures were made, of 1, 2, 3, 4 and 5 minutes' duration respectively, all on one plate. It was found that the intensity of the D_2 line for the 4-minute exposure was only slightly greater than that of the D_1 line for 1 minute, while the 8-minute D_1 line was certainly less intense than the D_2 1-minute line. This means that the D_2 line is between 8 and 4 times as intense as the D_1 line, the intensity ratio being probably about 8.75. Experiments with a flame rich in sodium showed that the intensity of both lines was very nearly the same. A. W.

1251. Absorbing Power of the Arc for its own Radiations. G. Gouy. (Comptes Rendus, 158. pp. 1057-1060, April 14, 1914.)—The visible rays from an impregnated carbon arc are dispersed by a grating and examined ocularly on a screen alongside a continuous spectrum formed by an auxiliary collimator carrying two nicols. The continuous spectrum can thus be matched with the arc spectrum. The intensity I of the direct beam is measured, and by means of a mirror arranged at the back of the arc a beam is reflected through the arc and the intensity I' again measured. If K is the fraction of the light intensity transmitted by the direct and reflected rays, $2K$ is the absorbing power and $K = 1 + 1/R(I'/I - 1)$, where R is the reflecting power of the mirror.

In particular the rays of calcium between 5188.9 and 6462.2 Å. and of strontium between 4607.3 and 5486.2 Å. have been examined and the value of $2K$ varies from 0.11 to 0.64. The absorbing fraction lies between 0.5 and 0.7 for the more intense rays but is smaller for the feebler ones. Regarding each ray as the maximum of a continuous function decreasing on either side of the spectrum, and therefore containing rays for which the absorbing power is small, it will be seen that the absorption of the principal ray must necessarily remain inferior to unity. C. S. G.

1252. Complex Structure of Spectrum Lines. C. Wali-Mohammad. (Astrophys. Journ. 39. pp. 185-208, April, 1914.)—The spectra of fifteen metals have been examined, using an echelon grating and a monochromator. Photographic measurements are obtained conveniently with short exposures by employing the oxy-kathode source and the readings taken with a Zeiss microscope. Most of the lines are simple and none of the metals show the same abundance and complexity of satellites as mercury. Some of the lines exhibit symmetrical, while others show unsymmetrical, self-reversal. In a few cases it is shown that lines previously thought to be satellites are to be attributed to such reversals. C. S. G.

1253. Differences in the Polar Spectra of Various Elements. B. Reismann. (Zeitschr. wiss. Phot. 18. pp. 269-311, March, 1914.)—The spectra exhibited at the different locations in a Geissler tube are photographically examined for
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the following elements and compounds : chlorine, bromine, iodine, hydrogen, oxygen and nitrogen ; the vapours of Bi, Sb, Cd, Zn, Hg, Ag, and Pb ; carbon monoxide, hydrochloric acid, carbon tetrachloride and stannic chloride ; and, in general, differences are observed in the spectra at the poles and in the positive column. The halogens show line spectra at the kathode only, which correspond generally to the spark spectra of the elements, but otherwise continuous spectra are obtained. For the halides the results correspond to those of Stead [Abstract No. 1483 (1911)]. Oxygen shows only the series spectrum in the positive column ; at the kathode, however, the series, the elementary line and the band spectra appear. Nitrogen is characterised by an especially marked negative band spectrum at the anode, whilst in hydrogen differences in intensity only are observed at the two poles. The metallic vapours all give band spectra throughout the tube, but whilst the arc lines appear throughout, the spark lines seem only to occur at the kathode. Carbon monoxide when present as an impurity seems to be concentrated in the positive column.

C. S. G.

1254. *New Ultra-violet Absorption Spectrum of Oxygen.* L. and E. Bloch. (*Comptes Rendus*, 158. pp. 1161–1164, April 27, 1914. *Le Radium*, 2. pp. 97–100, April, 1914.)—By making long-exposure (up to 6 hours) short wave-length spectrograms of the spark spectra of Bi, Al, Cd, Sn, and Tl, and of the positive crater of the carbon arc it is found that certain dark bands of lines appear, which are constant in position and appearance, although the relative intensities of the lines vary for the different light sources. These bands are attributed to the absorption of the oxygen of the air from the continuous spectra, which for different sources have different intensities. Steubing [see Abstracts Nos. 64 (1911), and 599 (1918)] has attributed the light spaces between these lines to short-waved fluorescence of oxygen, but the authors have failed to obtain any indication of such fluorescence, using a quartz mercury lamp and exposing for 8 hours. To the five bands observed by Steubing between 1881 and 1919 Å. two new bands at 1923·4–1936·5 and 1946·5–1957·4 Å. have been added. The bands, both old and new, have the same structure and conform to a Deslandres' formula, for which the constants are obtained.

C. S. G.

1255. *Combined Effect of Electric and Magnetic Fields on Spectrum Lines.* J. Stark. (*Deutsch. Phys. Gesell., Verh.* 16. 7. pp. 827–832, April 15, 1914.)—The helium line $\lambda 4471\cdot646$ was found by Lohmann [Abstract No. 617 (1908)] to yield a normal Zeeman triplet in the transverse effect ; but when subject to an electric field of from 20,000 to 80,000 volts/cm. the line gives a quartet with two components oscillating parallel to the field and two perpendicular to it. Two cases of the transverse effect occur with superimposed electric and magnetic fields : (1) Electric and magnetic fields parallel to one another. The question then arises as to whether in this case the two electric components of the line oscillating perpendicular to the electric field are each separated into a doublet by the magnetic field, while the two components oscillating parallel to the electric field remain unaffected, or does another kind of electromagnetic separation take place. (2) Electric and magnetic fields perpendicular to one another. Do the two electric components oscillating parallel to the electric field each split up into a doublet under the action of the magnetic field, the two perpendicular components remaining unaffected, or does another type of separation occur here ? Experiments are being undertaken with a view to elucidating these problems. It was found that by

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the admission of a certain amount of hydrogen to the helium in the discharge tube the light emission of the canal rays in the mixture is more intense than in pure He. A description is given, with diagrams, of the apparatus to be used for investigating the combined effect of the electric and magnetic fields. The results of the experiments will be published later. [See Abstract No. 288 (1914).] A. W.

1256. *Lithium Doublets and Effect of Magnetic Field.* N. A. Kent. (Phys. Zeitschr. 15. pp. 883-885, April 15, 1914.)—In continuation of the work of Paschen and Back on doublet and triplet series [see Abstracts Nos. 419, 1282 (1918)] a study was made of the lithium line $\lambda 6708\cdot 2$ found by Zeeman in the absorption spectrum to be a double line with the wave-length difference $0\cdot 144$ Å. unit. The research showed that the four lines $\lambda 6708\cdot 2$, $\lambda 6108\cdot 77$, $\lambda 4972\cdot 11$, $\lambda 4602\cdot 87$ are members of a doublet series and correspond to the doublets of the other alkali metals, the wave-length differences being respectively $0\cdot 151$, $0\cdot 114$, $0\cdot 084$, and $0\cdot 069$ Å. unit. In high fields the lines give normal Zeeman triplets, as was previously found by Back, who used the spark in air as the source of light. The sources of light used in the present experiments were a Geissler tube and a vacuum arc-lamp. A. W.

1257. *Zeeman-effect for Series Lines.* W. Voigt. (Ann. d. Physik, 43. 8. pp. 1187-1164, April 16, 1914.)—A theoretical treatment referring specially to the sodium doublets and the oxygen triplets $\lambda 8947$. A general coupling theory is discussed. [See also Abstracts Nos. 1440 and 1826 (1918).] A. W.

1258. *Light Absorption and Fluorescence.* E. C. C. Baly. (Phil. Mag. 27. pp. 682-645, April, 1914.)—It has previously been shown that it is possible for one substance to exhibit different absorption bands when dissolved in different solvents. If, for example, certain aromatic amino aldehydes and ketones are dissolved in alcohol their solutions exhibit characteristic absorption bands in the ultra-violet region. If now to these alcoholic solutions a small quantity of an alcoholic solution of HCl is added, the quantity being much less than is required to convert the whole of the amino compound into the hydrochloride, a second absorption band is developed of longer wave-length. The addition of a further quantity of HCl changes the absorption to that characteristic of the hydrochloride of the base. An exactly similar phenomenon was observed in the case of the sulphonation of certain benzene compounds. The fact that more than one absorption band is given by one and the same substance in different solvents gives at once a reasonable explanation of phosphorescence and fluorescence. The various absorption bands exhibited by the same substance represent various free periods of vibration possessed by the same substance. If now a substance in alcoholic solution exhibits an absorption band, and if it is absorbing light of this frequency, it is reasonable to expect that some of the vibrations corresponding to greater stages in the opening up of the closed force field of the atoms are brought into play, and hence the substance will fluoresce with emission of light of wave-length corresponding to the more opened-up phases. The wave-length of the light absorbed by a substance when opened up to a greater stage by solution in a suitable solvent should therefore be the same as the fluorescent light emitted in alcoholic solution when it is only opened up to a lower stage. This has actually been found to be the case, for the fluorescent light emitted by a number of compounds in alcoholic solution is the same as that absorbed by them when in solution in sulphuric acid. Similarly the wave-length of the fluorescent light emitted by the alcoholic solutions of the amino aldehydes and ketones is

the same as that absorbed by them in the presence of traces of HCl. It follows from this that the fluorescent spectrum of a compound will give a measure of a wave-length of the absorption band of that substance when opened up to a greater stage. Only a few substances have been found up to the present in which more than two absorption and fluorescent maxima have been measured, but in each of these there exists a constant frequency-difference between these maxima. A large number of compounds, for which only two maxima of absorption and fluorescence are known, show a frequency-difference of 400 or some multiple of 400. Further research on these lines is in progress. An explanation of this is suggested, based on the quantum theory. Further experimental verification may be sought in the refractivities of compounds, which Sellmeyer has shown can be connected with an absorption band in the ultra-violet. The refractivities of Cl, HCl, water-vapour, NH_3 , N_2O , and N_2O have recently been given by C. and M. Cuthbertson [Abstract No. 1642 (1913)], and their values are found to be in good agreement with those calculated from a modified form of Sellmeyer's formula, use being made of the wave-lengths of the infra-red absorption bands of the different substances. The existence of absorption bands and fluorescence maxima with constant frequency-differences and the results of the above calculations seem to show fairly conclusively that the application of the quantum theory to absorption spectra observations is thoroughly justified. Many interesting deductions may be made from this application. Thus, since it would seem that phosphorescence and fluorescence only differ in the relative velocity and absorption of the energy, and since the emission of infra-red radiation appears to be intimately connected with absorption in the ultra-violet, it is to be expected that the converse would be true. This may give an explanation of the well-known fact that the phosphorescence of a substance after exposure to an exciting cause is at once destroyed on exposure to infra-red radiation. Also, since refractivity and magnetic rotation are bound up with chemical structure, it should be found possible on the above grounds to connect these properties with absorption and constitution more intimately than has hitherto been found possible. A. W.

1259. Decay of the Luminescence of Coloured Gelatine. A. Pospelow. (Deutsch. Phys. Gesell., Verh. 16. 9. pp. 411-420, May 15, 1914.)—By means of a phosphoroscope of the Wiedemann type used in conjunction with a spectrophotometer the intensity of the green band in the spectrum of the phosphorescent light emitted by gelatine coloured with eosin was determined at various intervals after its illumination with light from an arc. The gelatine was prepared in the form of thin films adhering to glass surfaces. The intensity of the emitted light was found to be an exponential function of the time. Films suspended in an atmosphere of water-vapour gave much larger decay coefficients than films which had been carefully dried. F. J. H.

1260. Asymmetric Distribution of Secondary Electronic Radiation produced by X-radiation. A. J. Philpot. (Phys. Soc., Proc. 26. pp. 181-186, Feb., 1914.)—It has been found by several investigators that the amounts of electronic radiation given off on the two sides of a sheet of metal, exposed to a beam of X-rays, incident normally upon it, are not equal, but that, when due allowance has been made for the absorption of the X-radiation in the sheet itself, there is a preponderance of electronic radiation emitted in the original direction of propagation of the X-radiation. There is, however, a disagreement amongst various observers as to the extent of this asymmetry.

In the present investigation an attempt is made to arrive at more definite results. The radiations used had mass absorption coefficients in aluminium ranging from 0.5 to 5.0. The values obtained for the ratio of the emergent to the incident electronic radiations were found not to differ much from the value 1.18 arrived at by Cooksey [see Abstract No. 1585 (1912)], but in general an increase of hardness of the exciting X-radiation was found to correspond with an increase of asymmetry. Such increase, however, was very slight compared with the increase in penetrating power of the exciting radiation.

E. A. O.

1261. *Röntgen Patterns of Boracite, obtained above and below its Inversion Point.* H. Haga and F. M. Jaeger. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 792-799, March 26, 1914.)—It is attempted to find whether with polymorphic changes, principally in cases of enantiotropic inversions in the neighbourhood of the critical inversion temperature, a change of molecular arrangement takes place or whether the cause of polymorphism is to be attributed to a change in the crystal molecules themselves. The problem is investigated in the case of boracite, which is a crystal whose optical behaviour does not agree with the symmetry of its external form, its cohesion, etc., or in other words, its total crystallographic character. Boracite crystallises in forms, which, even by the most accurate goniometrical measurements, cannot be discerned from real hexakistetrahedral ones, whilst optical investigations, and also those concerning the corrosion phenomena, have definitely shown that crystals of boracite possess no regular symmetry in the ordinary way. At temperatures between 260° and 280° C. boracite suddenly becomes optically isotropic, and its optical properties are now in complete agreement with its external form. On cooling, the birefringence returns and the crystal resumes the case of an optically anomalous one. The crystal is investigated in the present instance by sending a beam of X-rays through it and photographing the pattern of it in the usual way. A detailed account is given of the furnace in which the crystal was heated. It was so arranged that a beam of X-rays could traverse the crystal at very high temperatures as well as at ordinary room temperatures. Experiments were only made with a plate of the crystal cut perpendicular to the binary axis, and if the crystal were really of a regular system such a plate must at the same time be also perpendicular to the quaternary axis. Laue photographs were taken of the crystal at room temperature and at about 800° C.; at this temperature the optically isotropic form was always present. It was found that there was a difference between the Laue patterns at these two temperatures, which indicates that, by heating to 800° C., there is a slight molecular rearrangement in the boracite crystal, and from this it is to be inferred that the dimorphism of the boracite is connected with a change in its molecular arrangement. Similar experiments with leucite are in progress.

E. A. O.

1262. *Röntgen-ray Reflection. II.* C. G. Darwin. (Phil. Mag. 27. pp. 675-690, April, 1914.)—In the former paper [Abstract No. 1082 (1914)] formulæ were obtained for the intensity of reflection by a crystal without taking account of the interaction of the atomic vibrations. This is here allowed for, and plane waves are assumed owing to the complexity of the problem, and justified by the observation that it is only necessary to find the amplitude of reflection at a point so distant from the crystal that in the principal part of the field the phases of waves from adjacent atoms are sensibly the same. This permits the summation to be replaced by an

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integration, while yet the point is not so distant that the crystal has to be regarded as finite; this introduces the Fresnel factors in the integral and makes it converge. Though not mathematically rigorous, there can be little doubt of the right value being so obtained, and it has the advantage that the formulæ do not involve the exact number of atoms in the whole plane, which is clearly irrelevant to the final results. The result of the interaction is an effect like that of an addition to the radiation term in the vibration of an electron. Now the radiation term scarcely affects the amplitude of an electron vibrating under the influence of Röntgen rays, so we may conclude that the mutual influence of atoms on a plane may be neglected, as might also be expected from the complete absence of phase relations of waves arriving at any one atom from the rest. Not so, however, for a combination of all planes. Then, when the radiation is at the angle of reflection, the waves reflected from successive planes are in same phase and should therefore give rise to a secondary reflection, and this is what was neglected in the first paper. Modified formulæ are now obtained giving practically perfect reflection within a certain angular range, and consequently a more rapid extinction of the transmitted beam than corresponds to the true absorption of the crystal. The new formulæ make the reflection independent of the absorption coefficient of the crystal, and Bragg [Abstract No. 672 (1914)] has proved that absorption plays an important part. The author seeks an explanation in the imperfections of a crystal, and when the effect of the irregularities to be expected is taken into account, the formulæ obtained differ from those of the first paper by a numerical factor only, and are taken by the author as the best approximation as yet obtainable.

G. W. DE T.

1263. *New Method of rapidly obtaining Spectra of Röntgen Rays.* M. de Broglie and F. A. Lindemann. (Comptes Rendus, 168. p. 944, March 80, 1914.)—A beam of X-rays, coming from a slit, falls on a sheet of mica rolled on a fixed cylinder, whose axis is parallel to the slit. It is so arranged that the extreme rays on one side of the beam fall tangentially on the surface of the cylinder. The different rays in the beam are reflected at different angles and register themselves in different positions on a photographic plate. The whole spectrum of the rays in the beam can be photographed in a few minutes by this method.

E. A. O.

1264. *Measurements of Intensity and Hardness of Röntgen Rays.* H. Kröncke. (Ann. d. Physik, 48. 5. pp. 687-724, March 18, 1914. Extract from Dissertation, Göttingen.)—The hardness of a beam of X-rays is generally measured by means of the simple formula $I = I_0 e^{-\lambda x}$, where λ is the coefficient of absorption of the rays. In practice, λ is given for a thickness of 1 cm. of a standard substance, whether this be the thickness of the layer used in the experiment or not. The author points out that there is a serious error introduced unless the coefficient of absorption is given in terms of the thickness actually employed in the measurement. The aim of the present investigation was to find how the hardness and intensity of X-rays could be defined in a manner free from this objection. With this in view, attention is given to the measurement of the voltage and current through the tube, and it was found that an exact measurement of these two quantities was sufficient to determine the hardness and intensity. Hence the chief aim of the work resolves itself into finding the relations which exist between the voltage and the current in the tube and the hardness and intensity of the rays.

The tube was driven by means of a constant continuous current which
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was obtained by Des Coudres' method of producing high-voltage continuous currents, but this method was improved upon by the use of a resonance transformer. Six different tubes were used in the investigation—some were water-cooled and fitted with carbon regulators, others were regulated by an arrangement similar to the Bauer valve. In the latter case a piece of glass tubing was fused into the wall of the X-ray tube, into which a small piece of clay was fitted. The whole was covered with mercury, which was held in a rubber tube passing over glass tubing. The clay allows air to pass through it, but not Hg. If the vacuum gets too low, a pressure is applied to the rubber tubing which makes it expand, thus lowering the mercury surface and exposing the clay to the air, which enters into the tube. This regulator proved invaluable throughout the work. Oscillograms showed that the current through the tubes was remarkably constant. Any degree of hardness of the tube could be established and reproduced at any time.

According to Simon, the characteristics of a tube may be divided into statical and dynamical: the former appearing with continuous current and the latter with non-continuous current. Characteristic curves showing the relation between the current passing through the tube and the voltage applied to it are given. When the tube is very soft the curve is nearly a straight line, except for very small values of the current. All the curves show a clear exciting minimum. After excitation, the voltage on the tube decreases and then gradually increases again. This behaviour of the characteristic curves was the same for all the tubes investigated. It was found that with hard bulbs the voltage on the tubes is only slightly dependent upon the current, and the hardness of the rays in this case would be almost independent of the voltage. It is pointed out that the initial potential required to light up the tube would be considerably lowered by warming the tube. The initial potential is also lower, the shorter the time since the last discharge of the tube. The flickering of an X-ray tube is to be explained by the fact that the voltage on the tube is almost roughly equal to the exciting voltage, so that it is not continuously above the "lighting up" point of the tube. This flickering can be removed by increasing the load, or, if this is impossible, by making the tube softer.

Very careful measurements were made of the ionisation currents obtained with various tubes under different conditions. The readings of the ionisation currents were made in the shortest possible time, and, so far as could be arranged, under similar conditions in each case. It was found that the intensity of the radiation was directly proportional to the current through the tube. This was tested in the case of all the tubes investigated, and found to be true for a wide range of potential. Great difficulty was experienced in finding the relation between the potential on the tube and the intensity of the radiation—the reason for this chiefly being, that the exciting potential increases rapidly with the increasing hardness of the tube. It was found, however, with sufficient accuracy for all practical purposes, that the intensity of the radiation from an X-ray tube is a quadratic function of the voltage on the tube. The relation may be represented by the formula $S = A(V^2 - V_0^2)$, where V_0 is a constant for the tube and A , a function of the current passing through it. Since A is a linear function of the current i , we may write this $S = Ci(V^2 - V_0^2)$ where C and V_0 are constants for the tube. With low potentials this relation between the intensity of the radiation and the square of the potential does not hold. Incidentally, the formula is in agreement with that of Whiddington, which states that the energy of the radiation is proportional to the fourth power of the velocity of the cathode rays, the potential V being proportional to the

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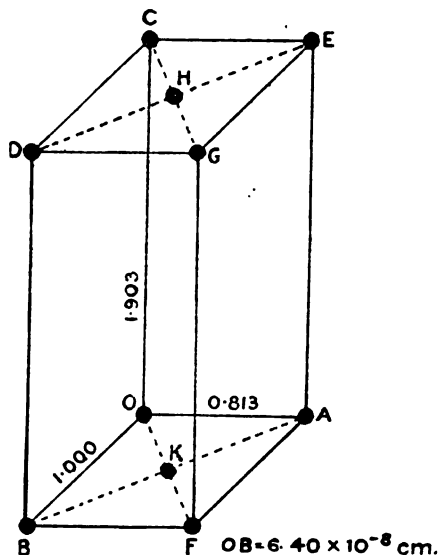
square of the velocity of the kathode rays. The homogeneity of the rays emanating from a tube has been examined previously by Adams, but in the present investigation the matter was entered into more fully. Care was taken to measure the intensity of the radiation under constantly maintained conditions of discharge. In no case were the rays found to be homogeneous even though the kathode rays producing them were homogeneous. This is simply explained by the fact that some of the kathode rays are stopped more suddenly than others owing to the fact that they fall on the atom more centrally. Homogeneity of the rays is out of the question even after they have penetrated an Al plate of 6 mm. thickness and have thereby been weakened to less than 1 % of their original intensity. The distribution of the energy in an X-ray spectrum was investigated by plotting the intensity as a function of the hardness (as measured by the absorption coefficient of the rays), and a theoretical formula is obtained for the portion of the total radiation having a given hardness. By measuring the absorption coefficient of the rays in various thicknesses of Al when the current through the tube was altered, it was established that the hardness did not depend at all upon the current. This holds for voltages ranging from 15 to 40 kilovolts. It was also observed that the distribution of the rays in the spectrum was independent of the current in the tube. The hardness of the rays is completely defined by the voltage. The degree of the vacuum which exists in the tube, the construction of the tube, and like things are in themselves without influence on the hardness of the rays: they are only of secondary influence in so far as the voltage on the tube depends upon them. The same voltage may exist on a tube with quite different degrees of evacuation, provided only that the amount of current is suitably chosen. Hence, with various pressures of gas in the tube, the hardness of the rays may be the same. A graph is drawn showing how the hardness defined by the absorption coefficient in various thicknesses of Al depends upon the voltage. The degree of non-homogeneity of the rays is not markedly dependent upon the voltage. A comparison of the results with various tubes showed that for the same current the amount of energy given out by some was much larger than by others. It seemed probable that this behaviour might be due to the different thicknesses of the walls of the tubes. Accordingly the intensity of the radiation from various tubes having the same thickness of antikathode when the same current and voltage were applied to them, was plotted as a function of the thickness of the glass wall. From this curve the relative efficiencies of the tubes could be estimated. We may write the equation giving the intensity of the radiation in the following form: $S = k/r^2 \cdot f(d) \cdot i (V^2 - V_0^2)$, where k is the emissive power of the metal of the antikathode in the direction considered, r the distance between the ionisation chamber and antikathode, and $f(d)$ is a function of the thickness of the glass wall. If the intensity S were measured in absolute units, then by means of the above equation the emissive power of the antikathode in the particular direction chosen could be calculated in absolute units, since we know $f(d)$ from the curve. By comparison with the Benoist scale, it can perhaps be said that with a continuous current passing through the tube, rays of a medium hardness would correspond to a voltage of about 50 kilovolts, and hard rays to a voltage of about 80 to 100 kilovolts.

The investigation is extended so as to include the effect of X-rays on photographic plates. Up to the present we may summarise our knowledge on this point by saying that the blackening of a photographic plate under otherwise similar conditions is less, the harder the rays. In order to investigate quantitatively the action of the rays on photographic plates, the plates had to

be exposed, developed, and finally measured under rigorously defined conditions. Schleussner's X-ray plates were used. The chief point in this connection was to maintain a well-defined condition of discharge in the X-ray tube for a considerable time. This was done by the method already alluded to; by careful manipulation of the air inlet valve, the variations of the voltage could be kept to within 6 %. A detailed account is given of the method of exposing and developing the plates, and of measuring the blackening produced. It was found that for Schleussner's X-ray plates the Bunsen-Roscoe law holds—namely, that equal photochemical actions correspond to equal amounts of energy. A graphical representation is given of the investigation of the problem of how the blackening of the plate by X-rays of constant intensity is dependent upon the voltage on the tube. It is finally pointed out how erroneous the measurements of hardness based on the measurements of photographic blackening can be. It is shown that the photographic measurements exhibit discrepancies up to 50 % compared with those found by the ionisation method.

E. A. O.

1265. *X-ray Spectra given by Sulphur and Quartz.* W. H. Bragg. (Roy. Soc., Proc. Ser. A. 89, pp. 575-580, March 2, 1914.)—A number of results of examination of crystals by means of the X-ray spectrometer have recently been given by W. L. Bragg [Abstract No. 876 (1914).] The cases which he has considered are those in which the information has been sufficient for a complete solution of the crystal structure. The present note deals with



two cases, viz. sulphur and quartz, which have not been completely solved but which have nevertheless given interesting results. The method employed consists in observing the angle at which X-rays of known wave-length are reflected from the faces of the crystal. The faces used are not necessarily natural faces but may be obtained by rubbing down, on sand-paper for instance, in directions suggested by general crystallographic evidence. The angles of reflection give the distance from plane to plane of atoms in the crystal, etc. [see Abstract No. 86 (1914)]. The sketch gives

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the arrangement of the atoms in ordinary orthorhombic sulphur [$OB = 6.40 \times 10^{-8}$ cm.]. The evidence shows that there are eight lattices similar to the one shown, and that these lattices interpenetrate each other. However, no data are available at present for proceeding further with the calculation of the relative positions of the eight lattices.

The structure of quartz is similarly dealt with.

E. M.

1266. X-ray Spectra. G. E. M. Jauncey. (Nature, 98. p. 214, April 80, 1914.)—The author discusses some results of Herweg [Abstract No. 877 (1914)], who found that two lines in the X-ray spectrum of tungsten have almost the same wave-lengths as two of the lines of Pt. Assuming that X-ray spectra of different elements are similar and that corresponding wave-lengths are in the ratio of the squares of the atomic weights, it is deduced that the lines β and δ of Pt have nearly the same wave-lengths as the α and β lines respectively of tungsten, thus explaining Herweg's result.

E. M.

1267. Action of Radium Rays on Bakelite. C. E. S. Phillips. (Nature, 98. p. 295, May 21, 1914.)—A disc 4.2 mm. thick of the light yellow variety of transparent bakelite was cut from a rod, polished and then radiated with β - and γ -rays from radium. The colour of the disc darkened to a wine-red after 8 days, and exhibited an absorption band $\lambda = 5700$ – 6000 , which was not visible at first. The spectrum beyond $\lambda 4900$ Å. was also obliterated. The colouration extended to a depth of 2 mm., and it could be completely removed by exposure to a temperature of 100°C . for about 8 hours. The effect appears due to the direct action of the β -rays and the author suggests that the new substance may prove to be a useful filter for therapeutic use, especially as it is cleanly and easy to work.

E. M.

1268. Range of α -Particles in Air at Different Temperatures. A. F. Kovarik. (Le Radium, 2. pp. 69–71, March, 1914.)—Polonium was used as source of α -particles, the ranges being determined at temperatures varying from 90° abs. to 362° abs. The method employed was that of Geiger and Nuttall [Abstract No. 168 (1912)] in which the source is placed at the centre of a large bulb, and a curve obtained connecting the ionisation current and the pressure of air inside the bulb. The curve shows a marked point of inflection at the pressure when the α -particles just fail to reach the walls of the bulb. From the radius of the bulb the range at atmospheric pressure can be deduced by assuming that range is universally proportional to the pressure. The results show that the range is practically proportional to the absolute temperature, as might have been anticipated from density considerations.

E. M.

1269. Numerical Determination of the Absorption and Reflection of β -Particles by Matter. A. F. Kovarik and L. W. McKeehan. (Phys. Zeitschr. 15. pp. 484–440, May 1, 1914.)—The numbers of β -particles transmitted by sheets of Al and Sn of various thicknesses were determined by Geiger's method [Abstract No. 1878 (1918)], using RaE or the active deposit of thorium as source. In both cases the absorption was not according to an exponential law, the β -particles becoming more absorbable as the absorption proceeded. The β -rays reflected from various substances were also found to be numerically more absorbable than the primary rays. The number of β -particles reflected by thick sheets of matter of different elements was found to increase with the atomic weight (Al to Pb) in nearly the same manner as when measurements are made by the ionisation effect of the

reflected rays. This shows that the decrease in velocity of β -particles by reflection is practically independent of the reflecting material. E. M.

1270. *Saturation-curve in Ionisation by α -Rays.* G. Jaffé. (Phys. Zeitschr. 15. pp. 858-860, April 1, 1914.)—The paper deals with further experiments to test the author's deductions regarding the saturation-curve in the case of ionisation by α -rays, the theory being based solely on the idea of columnar ionisation without any assumption of initial recombination. The α -particles investigated were canalised very carefully, and uniform electric fields used. The results show that the "columnar ionisation" theory is satisfied accurately for air with fields parallel to the ionisation columns and with various distances between the electrodes. [See Abstracts Nos. 821, 712 (1914).] E. M.

1271. *Absorption of γ -Rays.* S. Oba. (Phil. Mag. 27. pp. 601-607, April, 1914.)—The object of the present experiments was to investigate whether or not γ -rays are changed in their quality by passing through matter. For this purpose the absorption by Al and Fe was determined both for the primary γ -rays of Ra and for the rays after passage through different thicknesses of "hardening" materials such as Cu, Sn, and Pb, since it is known that these metals apparently decrease the absorption coefficient in Al of γ -rays which have passed through them. The results may be summarised as follows:—(1) The absorption coefficient in Al for the primary γ -rays decreases gradually with increasing thickness up to 6.6 cm. Al and is then practically constant up to 16 cm. ($\mu/\rho = 0.0428$), while that in Fe continually decreases with increasing thickness. (2) The material through which γ -rays were first passed acts in all cases to harden the rays. (3) The decrease of the value of μ/ρ [i.e. (2)] becomes more pronounced for larger thicknesses of the absorber, but the decrease appears to tend to a limiting value. (4) The γ -rays which have been hardened become gradually softer by passing through increased thickness of absorber. Moreover, particularly in the case of Fe, it is possible that the hardened γ -rays may tend, with large thickness of absorber to the same penetrating power as that to which the primary γ -rays tend. The author considers the results as due to excited γ -rays in the absorption sheets, i.e. a transformation of part of the original γ -rays. Such excited rays will be in all cases softer than the rays producing them, and the issuing rays will reach a state of equilibrium when the proportion of primary rays and of softer excited rays has a certain definite value. In the case of Al as absorber, for example, when the rays have previously passed through a hardener of high atomic weight they will have been robbed of the greater part of the softer constituents, so that as they pass through the Al, more and more soft radiation will be excited until equilibrium is established. The rays will therefore apparently become softer, as the experiments show. E. M.

1272. *Activity of freshly-formed Radium Emanation.* H. H. Poole. (Phil. Mag. 27. pp. 714-718, April, 1914.)—As there is no very satisfactory explanation of the exponential law of radio-active decay, it is not unreasonable to suppose that variations from it might occur under certain conditions. For instance, as has been suggested by Joly, it is possible that the rate of decay, and hence the activity of a body, might be anomalous when the body is freshly formed so that its age is only a very small fraction of its average life. Accordingly, the author has compared the activity of RaEm a few seconds old with that of the same emanation at the age of a few minutes. The results were negative, nothing anomalous being detected. E. M.

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1273. *Refractive Index of Radium Emanation.* A. W. Porter and C. Cuthbertson. (Röntgen Soc., Journ. 10. pp. 2-9, Jan., 1914. Presidential address of A. W. Porter.)—The difficulties lay in the small quantity of gas available ($1/10$ mm.³) and the difficulty of keeping the gas pure. A specially-designed Fabry-Perot interferometer was used. The vessel into which the emanation was introduced had two plane-parallel faces (distance apart, e), partly silvered in the insides. The ordinary Fabry-Perot fringes were obtained with a vacuum between the plates, the emanation was then introduced and the refractivity determined from the number n of bright bands which passed over a fixed point in the observing telescope, i.e. $\mu - 1 = n\lambda/2e$. Owing to the difficulty of working with the pure emanation and to the limited supply available, no definite values have so far been obtained, but the results show that the refractivity of the emanation is higher than that of any other known gas and at least 25 times that of helium. From certain theoretical considerations of the ratios between the refractivities of the inert gases the authors conclude that the value ought to be about 40 times that of He. E. M.

1274. *Periods of Transformation of Thorium and Actinium Emanations.* P. B. Perkins. (Phil. Mag. 27. pp. 720-731, April, 1914.)—Since the transformation constant of a radio-active substance is determined from the equation $\lambda = \log_e I_0/I/t$, where I_0 is the initial activity, and I the activity after a time t , it is obvious that the relative error in λ is decreased as t is increased, provided I_0/I can be determined with the same degree of accuracy in each case. In practice the difficulty arises when I is a very small fraction of I_0 . In the present method this difficulty is overcome by using an adjustable capacity connected to the leaf system of the measuring electroscope. By diminishing the capacity as decay proceeds, readings can be taken more accurately. The final results for the half-value periods of ThEm and ActEm are 54.5 secs. and 8.92 secs. respectively. E. M.

1275. *Lead and the Final Product of Thorium.* A. Holmes. (Nature, 98. p. 109, April 2, 1914.)—It has been considered for some time that the final product of the Ur family is "isotopic," or chemically identical with Pb. The constancy of the Pb/Ur ratio in the case of primary rock-forming minerals of the same geological age, and its sympathetic variation in the case of minerals of different ages, go far to establish this important conclusion. The recent discovery that all the final products of radio-active disintegration fall into group IV. B of the periodic classification has naturally led to the further assumption that each one is isotopic with Pb. If this is the case, then the estimates of geological time, hitherto based on the Pb/Ur ratio, stand in need of revision. It is easy to calculate the relative rates at which Ur and Th generate their final products, and, assuming the latter are isotopic, to express a given quantity of Th in terms of Ur, and so to arrive at a "total equivalent quantity of uranium," U_0 , which also takes Th into consideration. On this assumption the ratio Pb/ U_0 ought to be constant for minerals of the same age, and ought to vary in sympathy with the ages if these should differ.

The author has examined a large number of analyses of radio-active minerals from this point of view, and neither of the above criteria is found to hold. Pb is absent in many thorium minerals. To throw more light on the question the author and R. W. Lawson are at present estimating the Th-content of a series of Norwegian minerals of Devonian age which have already been analysed for Pb and Ur. E. M.

HEAT.

1276. *Determination of the Melting or Solidifying Range of Temperatures of Lava.* K. Fuji and T. Mizoguchi. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 248-250, March, 1914.)—By means of an arrangement which simultaneously records both the temperature and electrical conductivity of lava the authors obtain the range of temperature over which the lava is melting or solidifying on the assumption, borne out by test experiments on molten NaCl, that the electrical conductivity of the molten lava increases proportionately with the decrease of viscosity. A curve in which current, representing conductivity, is plotted against temperature shows a point of inflection at about 1180° C. which, the authors consider, would correspond to the melting-point of a crystalline substance. The values given of the specific resistance at various temperatures are, in the neighbourhood of the melting-point, somewhat less than that of sea-water. The importance of this high conductivity in connection with its influence upon the propagation of Hertzian waves is pointed out. The results of the melting-point determinations are compared with observations made by one of the authors upon a lava stream from a volcano by means of a Holborn-Kurlbaum optical pyrometer. The results show that the optical pyrometer cannot be relied upon for such measurements.

F. J. H.

1277. *The Boiling-point of Sulphur on the Thermodynamic Scale.* M. Eumorfopoulos. (Roy. Soc., Proc. Ser. A. 90. pp. 189-208, May 1, 1914.)—The author has supplemented his previous determinations [Abstract No. 88 (1909)] by using silica bulbs instead of glass. The results he obtains are: The boiling-point of sulphur on the Centigrade thermodynamic scale is 444.61°, and the melting-point of ice on the absolute Centigrade thermodynamic scale is 278.18°.

A. F.

1278. *Specific Heats of Certain Binary Liquid Mixtures.* A. Campetti. (N. Cimento, 7. Ser. 8. pp. 97-107, Feb., 1914.)—The specific heats of binary mixtures of alcohol with diphenylamine, nitronaphthalene, α -naphthylamine and salol are greater than the values calculated by means of the law of mixtures [see Schulze, Abstract No. 781 (1912)]. The liquefaction of solid diphenylamine and α -naphthylamine is accompanied by rapid change in the specific heat, but this is not found to be the case with the above mixtures containing these compounds. Where the temperature of a mixture is lower than the melting-point of one of its components, the latter has the specific heat which it would have in the superfused, and not in the solid, state at the same temperature; to some extent, this behaviour is the inverse of that of water which, as water of crystallisation, exhibits approximately the specific heat of ice, and not that of water, at the temperature of observation.

T. H. P.

1279. *Ion Clouds in Moist Expanded Air.* G. Quincke. (Deutsch. Phys. Gesell., Verh. 16. 9. pp. 421-428, May 15, 1914.)—A general discussion of the behaviour of swarms of ions in the condensation experiment from which the author concludes as follows:—(1) The droplets do not fall with constant

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velocity in vertical paths, but are disturbed by air vortices and possibly by illumination. (2) It is not justifiable, from the sinking speed of the cloud, to calculate the size and number of the droplets.

E. H. B.

1280. *Matter in the Superfused State and Discontinuity of some of the Physical Properties in the Neighbourhood of the Melting-point.* R. Nasini and U. Bresciani. (N. Cimento, 6. Ser. 6. pp. 437-448, Dec., 1918.)—The behaviour near their melting-points of various substances which exhibit marked superfusion has been examined, especially as regards the "Moreschini effect," or the diminution occurring in the rate of cooling. The substances investigated were thymol, anethol, acetic, palmitic, formic, lauric and myristic acids, benzene, phenol, salol, apiol, cinnamic alcohol, sodium acetate and thiosulphate, water, and sulphur. All of these show pronounced superfusion, excepting lauric and myristic acids, with which the phenomenon is uncertain and in any case slight, and palmitic acid, which could be kept superfused over a temperature interval of only a degree. With acetic acid, anethol and thymol, either pure or mixed with small proportions of water or benzene, retardation of the fall of temperature at the melting-point is verified, but there is less certainty in the case of palmitic acid. With the remaining compounds, slight irregularities do apparently occur near their melting-points, but more exact experiments are necessary to decide if these variations are accidental or are of the same nature as, although smaller than, those mentioned above. Density determinations show that, with thymol, anethol and acetic acid, the variation of the volume with the temperature on either side of the melting-point is quite regular. With acetic acid and anethol, the specific heat exhibits a maximum at the melting-point and slightly below the melting-point respectively. Calculation of the coefficients of association of acetic acid, anethol and thymol from the surface tension according to Ramsay and Shields' method shows that the temperature interval including the melting-point corresponds with the most simple molecular magnitude.

The Moreschini-effect seems to be due to a tendency to crystallisation which does not materialise owing to the paucity and smallness of the nuclei; the development of heat is apparently due to the formation of these nuclei.

T. H. P.

1281. *Lower Limits of Inflammation of Methane with Mixture of Oxygen and Nitrogen.* A. Parker. (Chem. Soc., Journ. 105. pp. 1002-1009, April, 1914.)—By lower limit of mixture the author, in accord with Coward, understands the smallest possible quantity of combustible gas in which self-propagation of flame "upwards" will take place indefinitely after the original source of ignition has been removed. In the case of methane this lower limit is almost identical with that of Burgess and Wheeler [see Abstract No. 512 (1912)], the chief features of whose apparatus are retained by the author. The induction-coil spark is produced in a 2.5-litre bulb, between platinum points; the magnet and the electrical conditions are kept constant. The gases (methane from aluminium carbide) are purified. The inflammation curve (lower limit of methane as ordinate, oxygen percentage in air mixtures as abscissa) descends rapidly as the oxygen percentage increases to 20 per cent., and rises again very slowly as this percentage increases further. The minimum lies at 5.77 per cent., the adiabatic lower limit of methane would be about 2 per cent.; the excess of 3.77 per cent. being accounted for by the heat conducted away to the surroundings and by the energy given out as

radiant energy. The lower limit is found to be greater with oxygen than with air; this cannot be explained from the absorptive power for radiant heat, which is small and nearly the same for nitrogen as for oxygen. Thus the author differs in some respects from Dixon and Coward, and it is possible that the ignition temperature of a "mixture" of methane and oxygen is different from that of a "jet" of methane in an atmosphere of oxygen.

H. B.

1282. *Ignition of some Gaseous Mixtures by the Electric Discharge.* H. F. Coward, C. Cooper, and J. Jacobs. (Chem. Soc., Journ. 105. pp. 1069-1098, April, 1914.)—The experiments, made with mixtures of hydrogen and oxygen in all proportions, with electrolytic gas to which N , CO_2 , A are added, with mixtures of CO and oxygen, alone and diluted by other gases, and with mixtures of oxygen with cyanogen, methane, ethylene, show the complexity of the phenomenon. The experiments concern the pressure at which ignition becomes impossible, under the conditions of the ignition, when the gas pressure is lowered; his lower limiting pressure depends upon the conditions of the electric discharge. To obtain comparable results the same induction coil giving a 1.5 cm. spark with 4 volts in the primary was generally used. In the $H-O$ mixture, the ignition pressure rapidly fell off as the oxygen percentage increased; for the proportion 80 to 85 per cent. of oxygen the ignition pressure became almost constant. But electrolytic gas at 80 mm. pressure could be inflamed after the addition of 28 mm. of electrolytic gas itself, of from 8 mm. to 720 mm. of oxygen, and of from 90 to 210 mm. of hydrogen. Further, electrolytic gas which was no longer inflammable became so after certain additions of N , CO_2 , A . There is apparently in general no correspondence between ignition pressure and ignition temperature; the thermal conductivity of the mixture becomes significant when the pre-flame period is sufficiently long; an increase in the hydrogen percentage shortens this period; the influence of the specific heat is not considerable, except in the case of CO_2 ; the heat of reaction and the flame temperature are of little influence in the initiation of a flame in the explosive mixture. The energy of the electric discharge is a very important factor, but very little information is available. The effect of the spark is perhaps (Kaufmann) more mechanical than thermal. The general conclusion drawn is that the ignition of a mixture (the composition of which does not approach too near the dilution limit of inflammability) is determined chiefly by two factors: the thermal conductivity and the energy degraded when the discharge is passed; a third factor may be the activation (atomisation) of the oxygen, but this assumption rests chiefly on the experiments with carbon monoxide. The experiments do not show whether ignition is ultimately a thermal or an electrotonic effect, or, if electrotonic, the ignition is the result of the high degree of compression in the path of the discharge, due to the mutual repulsion of the electrons. The cooling influence of a diluent becomes marked only when the composition of the mixture approaches the dilution limit of inflammability, and a true flame once initiated in a homogeneous mixture will be propagated except in very narrow vessels. An appendix deals with the calculation of flame temperatures based upon Bjerrum's data for specific heats and dissociations.

H. B.

1283. *Vapour Pressure of Nitrogen Peroxide.* A. C. G. Egerton. (Chem. Soc., Journ. 105. pp. 647-657, March, 1914.)—The vapour pressures of solid nitrogen peroxide have been measured at temperatures ranging from -85°

to -100° , the method employed consisting in the saturation of a known volume of hydrogen passed over the peroxide and estimation of the amount of the latter carried over. With fall of temperature the vapour pressure decreases somewhat more rapidly than would be expected, and the results obtained lie on the curve, $\log p = 14.9166 + 0.6040$. Comparison of these results with those obtained above -85° by previous investigators shows that the slopes of the curves differ, although the individual measurements at about -80° are in agreement. The vapour pressures between -60° and -40° have been measured statically and are in accord with those found by the dynamic method. Further, the results agree with those calculated, according to Ramsay and Young's law, from measurements of the vapour pressure of water. The values obtained are in agreement with those of Scheffer and Treub for the solid [see Abstract No. 518 (1912)], if their two lowest values, which do not obey the Ramsay and Young equation, are considered slightly too high. With the aid of Nernst's vapour-pressure equation, approximate values are derived for the chemical constant, the latent heat of vapourisation, the molecular heat, etc., of nitrogen peroxide, but further data are required before accurate numbers can be obtained.

T. H. P.

1284. *New Relation between the Critical Quantities : Unity of all Substances in their Thermal Behaviour.* J. J. van Laar. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 808-822, March 26, 1914.)—The author discusses the deviations from van der Waals' ideal equation of state and suggests that these are caused by the variability of b with the volume and temperature. On the assumption that $b = f(v)$, it is shown that (1) $v_k - b_k = 2b_0$, where v_k is the critical volume and b_k and b_0 the values of b in the critical state and at absolute zero respectively; (2) $b_k/b_0 = 2\gamma$, where γ is the straight diameter expressed by $[\frac{1}{3}(d_1 + d_2) - 1]/(1 - m)$, d_1 and d_2 being the reduced densities of liquid and vapour and m the ratio of the absolute temperatures T/T_k . The values of γ are 0.9 for an ordinary substance, 0.75 for argon, and 0.5 for an ideal substance. Further, assuming that b is independent of the temperature and putting $f = (Td p/p dT)_k$, $s = RT_k : p_k v_k$, and $s' = v_k : v_0$, it is found that $2f = ss'$. Some of the values of these different magnitudes are as follows:—

	s .	s' .	f .
Ordinary substance	8.77	8.8	7.18
Argon	8.424	8.5	5.99
Ideal substance.....	2.667	8	4

The difference between s and s' is small but never negligible, and their empirical equalisation would lead only to approximate relationships, such as that of van der Waals. The above empirical relations, however, are perfectly exact and seem to hold accurately for all compounds.

Other simple relations derived are: (1) $f = 8\gamma$, the critical coefficient of pressure being always eight times the reduced coefficient of direction of the straight diameter; (2) $b_k = (b_k - b_0)^2/b_k v_k$ and (3) $-\beta''K = (b_k - b_0)/b_k$.

A table is given showing the values of the above magnitudes for limiting substances of high molecular weight, ordinary substances, oxygen, argon, hydrogen or helium, and an ideal substance.

T. H. P.

1285. *Tables of Thermodynamic Formulæ.* P. W. Bridgman. (Phys. Rev. 8. Ser. 2. pp. 279-281, April, 1914.)—The fundamental quantities, the relations of which are here tabulated, are ten in number: p , the pressure per unit area; τ , the absolute temperature; v , the volume of unit mass of the

substance ; Q , the heat absorbed ; $S = \int dQ/\tau$, the entropy ; W , the work done by the substance ; E , its internal energy ; $H = E + p\tau$, the total heat ; $Z = H - \tau s$, Gibbs' thermodynamic potential ; and $\Psi = E - \tau s$, the "free energy" of Helmholtz. The specific heats are not included, being first derivatives, $C_p = (\partial Q/\partial \tau)_p$, and $C_v = (\partial Q/\partial \tau)_v$, in the usual notation. Every such derivative has a definite meaning, involves three different variables, and the number of them is 720, connected by various relations, of which the general form is an equation between four of them and certain of the ten fundamentals. The number of such relations is, therefore, 11104865420, and any one can be easily found from tabulation of the 720 in terms of three selected derivatives. Those selected are the three given most directly by experiment : C_p , $(\partial v/\partial p)_\tau$, the isothermal compressibility ; and $(\partial v/\partial \tau)_p$, the isopiestic dilatation, the two latter being obtained from the characteristic equation, and C_p by additional calorimetric measurements. The 720 derivatives fall into ten groups, according to the variable remaining constant. Now each is of type $(\partial x/\partial y)_p$, where p fixes the group, and xy are any two of the other nine fundamentals. Write $(\partial x/\partial y)_p \equiv \partial x_p/\partial y_p$; then ∂x_p and ∂y_p may be tabulated separately as appropriate functions of the three selected derivatives, and the value for any desired derivative obtained by substitution for ∂x_p and ∂y_p , and taking the ratio. For if α be any variable which remains the same for the 72, $(\partial x/\partial y)_p \equiv (\partial x/\partial \alpha)_p/(\partial y/\partial \alpha)_p$. This reduces the number of expressions to be tabulated from 720 to 90, and this may be further reduced to 45 by imposing upon the auxiliary function α , as yet unrestricted, the restriction, $(\partial x)_p = -(\partial p)_\tau$. The α 's, so restricted, are not completely determined, but the derivatives are determined except that the entire collection of functions replacing the partial differentials may be modified by the addition of any factor, and this so chosen as to make the functions as simple as possible. The complete tabulation here indicated, with examples of its use, and auxiliary formulæ for simplifying the computation of any second derivative in terms of the four following second derivatives : $(\partial^2 v/\partial p^2)_\tau$, $\partial^2 v/\partial p \partial \tau$, $(\partial^2 v/\partial \tau^2)_p$, and $(\partial C_p/\partial \tau)_p$, are given in the paper. G. W. DE T.

1286. *New Formula for the Latent Heat of Vapours.* M. P. Applebey and D. L. Chapman. (Chem. Soc., Journ. 105. pp. 784-744, March, 1914.)—From the general thermodynamic equation combined with the equation of van der Waals, but assuming that the value of b in the latter is variable with temperature, the authors have obtained formulæ which enable the latent heat of vaporisation to be calculated from the volume relations of the substance in the liquid and gaseous states. The latent heats of non-associated substances calculated have been found to agree satisfactorily with the values of Young. The values of the van der Waals' constant b , and its variation with temperature, have been found for twenty-six normal substances, and for non-associated substances it is shown that the expression $1/v \cdot db/dt$ is approximately constant (v_0 being the extrapolated molecular volume of the liquid at the absolute zero of temperature). The halogen derivatives of benzene show anomalies which can be explained by the assumption that they are associated to a certain extent. A. F.

1287. *Black-body Radiation.* G. W. Walker. (Roy. Soc., Proc. Ser. A. 90. pp. 46-49, April 1, 1914.)—The author submits his empirical radiation function formula [Abstract No. 705 (1912)] to Fourier analysis, showing that the primary type of disturbance required to produce this energy distribution is a solution of the equation $\ddot{x} + 2n_0\dot{x} + n_0^2x = 0$, where n_0 is a quantity proportional to λ^{-1} . xvii.—A.—1914.

tional to the temperature θ , and this expresses the motion of an aperiodic dynamical system. If the constants in the formulæ of the author and of Planck are chosen so that they give the same value for Wien's constant $a = \lambda_m \theta$, and so that they agree at the maximum, they agree fairly well, as shown by the accompanying table.

λ/λ_m .	Planck.	Walker.
0.0	0.0	0.0
0.25	0.0004	0.0490
0.388	0.0117	0.1292
0.5	0.2217	0.4096
0.666	0.6802	0.7260
1.0	1.0	1.0
2.0	0.4054	0.4096
3.0	0.1384	0.1292
4.0	0.0564	0.0490
10.0	0.0022	0.0015
∞	0.0	0.0

Lummer and Pringsheim's observations [Abstract No. 370 (1901)] give results lying between the two theoretical curves, and slightly favouring the author's. Paschen's observations [Abstract No. 1049 (1901)] show good agreement with Planck's formula for any one wave-length at different temperatures; but he explains that in order to fit over his range from about μ to 9μ it must be assumed that, "for some unknown cause, the spectrum is weakened as wave-length increases, and that the observed values must be multiplied by increasing factors, the factor at 9μ being 1.8 as compared with 1 at μ . According to the author the facts suggest that his formula would make these factors unnecessary.

G. W. DE T.

1288. *Cyclic Processes between Infinite Neighbouring Isotherms.* K. v. Wesendonk. (Deutsch. Phys. Gesell., Verh. 16. 6. pp. 275-280, March 80, 1914.)—Mathematical.

1289. *Wien's Law.* R. Hargreaves. (Phil. Mag. 27. pp. 616-617, April, 1914.)—The proofs given usually lack generality as regards shape of enclosure or type of motion. The author deals with the mean effect for an enclosure of any shape, in which each surface element has an arbitrary normal component of small motion. In every small part of the volume, change of wave-length affects the radiation proportionally to dt . He then calculates, on the assumption of uniformity of energy content throughout the volume in respect to all wave-lengths:— $\Delta\lambda/\lambda = \Delta v/8v$; and $p\Delta v = E\Delta v/8v$. These give $(dE + p\Delta v)T = d(EX)/\lambda T = dS$ say, and if this be a perfect differential $E\lambda$ and S are functions of λT , so that $\lambda T = \text{constant}$ is the adiabatic relation.

G. W. DE T.

1290. *Rigorous Deduction of a Fundamental Relation in the Theory of Radiant Heat.* T. Levi-Civita. (Accad. Lincei, Atti, 28. pp. 12-21, Jan. 21, 1914.)—Mathematical.

1291. *Radiation Formulæ.* M. Wolfke. (Phys. Zeitschr. 15. pp. 463-464, May 1, 1914.)—A discussion in reply to the remarks by G. Krutkow [see Abstracts Nos. 445 and 909 (1914)].

E. H. B.

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SOUND.

1292. Sound Diffraction. G. W. Stewart and H. Stiles. (Phys. Rev. 8. Ser. 2. pp. 256-268, April, 1914.)—Describes experiments on this subject dealing with (1) the sound shadow of a sphere and the passage of sound through (2) narrow slits and (3) circular apertures. In the first case the agreement with theory was very good, and thus confirms the theory, and at the same time increases confidence in the Rayleigh disc, which was used in the experiments. In the second and third cases the results were not so concordant, and show the difficulty of securing satisfactory experimental conditions. [See Abstracts Nos. 885 (1912) and 1810 (1918).] E. H. B.

1293. Quincke's Interference Experiment. H. Riegger and J. Zenneck. (Zeitschr. f. physikal. u. chem. Unterricht. 26. 8. pp. 165-166, May, 1918.)—In this classic experiment with Quincke's tube it is recommended that the longitudinal vibrations of a rod clamped in the middle be used as the source of sound, and that a sensitive gas flame be used as the detector. The jet should be conical (of length nearly equal to the diameter), and the opening elliptical (say 1.5 mm. by 0.8 mm.), the gas pressure being about 82 mm. of water column. When indicating, this flame rises in a single, tall column, when not so disturbed it sinks to a low, two-pointed form. E. H. B.

1294. Influence of X-rays, etc., upon the Velocity of Sound in Gases. W. Küpper. (Ann. d. Physik, 43. 6. pp. 905-928, March 20, 1914. Extract from Dissertation, Marburg, 1912.)—An experimental research whose chief results may be summarised as follows:—The effect of X-rays upon air, oxygen, and nitrogen was shown to be a distinct increase of the velocity of sound, corresponding to a rise of 10% in the ratio of the specific heats. For hydrogen this value was exceeded. The ultra-violet rays of the mercury lamp, when used with oxygen, formed ozone, and thus gave a smaller sound velocity. The effects of radium and of an alternating field were within the experimental errors if existent. E. H. B.

1295. Quarry Explosion at Wiener-Neustadt. J. N. Dörr. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1688-1782, Oct., 1918.)—Deals with the distant effects of an explosion of about 150 tons of gunpowder in 1912. It was specially noticeable that between the inner and outer regions of audibility there extended a girdle or zone of silence whose width was from 100 to 180 km. E. H. B.

1296. Phonograph with Motor-drive and Repeat Action. R. Pösch. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1259-1265, June, 1918.)—Describes, by aid of two perspective views, the details of a modified type of the Archive Phonograph driven by a motor but with a mechanism easily permitting the repetition of any word or phrase so often required when the instrument is being used for serious study. [See Abstract No. 208 (1918).] E. H. B.

1297. Vibratory Motions under Incident Sound Waves. I. E. Waetzmann. (Deutsch. Phys. Gesell., Verh. 16. 9. pp. 424-430, May 15, 1914.)—Discusses the vibrations evoked from an asymmetrical elastic system by the incidence of sound waves of one or two frequencies. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1298. *Electronic Charge by Thermodynamical Method.* F. Wächter. (Ann. d. Physik, 44. 1. pp. 127-144, April 28, 1914.)—Indicates a method of approximating to the value of the electronic charge by mechanical and thermal considerations. E. H. B.

1299. *Diffusion of Electrons through a Slit.* J. H. Mackie. (Roy. Soc., Proc. Ser. A. 90. pp. 69-72, April 1, 1914.)—J. S. Townsend and H. T. Tizard showed how, by measuring the lateral diffusion of a stream of electrons in an electric field, it is possible to find the factor by which the energy of agitation of the electrons exceeds that of the surrounding molecules. In this work a small term was neglected, and the simplified form of the differential equation then solved. The present author examines the error introduced by this lack of rigour, and finds it to vary from 1 in 6000 to 1 in 25. [See Abstract No. 1462 (1918).] E. H. B.

1300. *Electric Charges less than that on the Electron.* F. Ehrenhaft. (Comptes Rendus, 158. pp. 1071-1078, April 14, 1914.)—By experiments on a precious metal in the colloidal state and the theory of the Brownian movements, the author calculates that charges exist less than those on the electron. The values of the charges found expressed in electrostatic units range as follows: 8.5, . . . 0.88, 0.69, 0.61, 0.14×10^{-10} . [See Abstracts Nos. 282, 508, 947 (1911), and 509 (1914).] E. H. B.

1301. *Determination of e/m for Canal Rays in Hydrogen.* W. Hammer. (Ann. d. Physik, 48. 5. pp. 658-686, March 18, 1914.)—The paper contains a fuller account of the experiments described in Abstract No. 870 (1912). Canal rays produced in hydrogen are allowed to pass into a vessel at a pressure of less than 10^{-4} mm. Hg as in the experiments of J. J. Thomson. The rays are first deflected by combined electric and magnetic fields so that parabolic patches of light are produced on a willemite screen placed in their path. By means of a universal spherical glass joint a small hole in the screen is adjusted to be on the parabola corresponding to H_+ . In this way a pencil of rays of definite velocity is obtained, even though the potential in the discharge tube might vary during the experiment. The velocity of the rays so obtained is measured by Des Coudres' method, which consists of the application of two electric fields at right angles to and distant from one another. These electric fields are connected to the same source of alternating e.m.f. so that the light produced by the rays on a screen placed beyond the electric fields assumes the form of an ellipse unless the time taken for the rays to travel the distance between the fields is equal to some simple multiple of the half-period of the alternating source, in which case the ellipse becomes a straight diagonal line. In the experiments rays were used with $v = 2.52 \times 10^8$ cm./sec., the pencil being homogeneous to $\frac{1}{4}\%$. The value found for e/m was 9755 which agrees, within the experimental error, with the value 9664 for the hydrogen ion in electrolysis. E. M.

1302. *The After-effect in Dielectrics.* K. W. Wagner. (Archiv f. Elektrotechnik, 2. pp. 871-887, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—A mathematical paper in which the author shows that the behaviour of an actual dielectric can be imitated by a model consisting of a matrix of perfect non-conducting dielectric with globules of imperfect conducting material embedded in it. F. T. C.

1303. *Measurement of Atmospheric Conductivity.* W. F. G. Swann. (Terrestrial Magnetism, 19. pp. 28-87, March, 1914.)—The best known method of measuring the conductivity of air is that devised by Gerdien, in which air is drawn through a cylindrical condenser, and the rate of movement of the leaf of an electroscope connected to the inner cylinder noted. Another method has, however, been developed at Potsdam, in which the conductivity is deduced by noting the rate of alteration of potential of a long, charged wire, surrounded by an earthed netting. This latter apparatus is readily applicable to automatic registration, but as the values of the conductivity as measured by this method at Potsdam are abnormally low the author has investigated the theory of its action. The netting is earth-connected in practice, and as it is situated some distance above the ground it has to take up a negative charge in order to maintain its potential zero. This charge will tend to spread out the negative ions as they are brought to the net by the breeze, with the result that too small a value of the conductivity will be obtained. The greater the air velocity, the less the error. Moreover, under very frequently occurring conditions, this form of apparatus is likely to give a value of the conductivity only about 60 % of the true value. With regard to positive ions, by the very same action that the net concentrates them into a denser steam, it attracts them to itself, and so prevents them entering the interior of the net. The action of the atmospheric potential gradient in causing a charge to appear on pieces of earth-connected apparatus is one which may make itself felt in many experiments. For instance, the ordinary Gerdien apparatus, when mounted on a pedestal some distance above the ground, must have a negative charge on the outer cylinder, and this charge will tend to widen out the stream of negative ions entering the cylinder and attract the positive ions to itself. Again the consideration is of importance in the action of a charged wire in collecting active deposit from the atmosphere. E. M.

DISCHARGE AND OSCILLATIONS.

1304. *Origin of Thermal Ionisation from Carbon.* O. W. Richardson. (Roy. Soc. Proc., Ser. A. 90. pp. 174-179, May 1, 1914.)—The paper is a criticism of the experiments of J. N. Pring on this subject and the conclusions he draws from them [see Abstract No. 528 (1914)]. The smallness of the thermionic currents observed at temperatures in the neighbourhood of 1800° C. and at very low pressures is due to the magnetic effect of the large current of 80 amps. employed to heat the carbon, it being shown that on account of the magnetic deflection none of the electrons emitted by the carbon would reach the collecting electrode. This effect may not be present at lower temperatures, but the minimum currents observed at these temperatures cannot from existing data be said to be smaller than those which would be called for by the ordinary thermionic theory. An increase of current with increasing gas pressure as found by Pring would be expected on account of both the interference of the gas molecules with the motion of the electrons

and the combination of the electrons with atoms and molecules of the gas; these would diminish the effect of the magnetic field. The large specific effects produced by traces of different gases seem to indicate that the combination of the electrons with atoms or molecules is an important factor; this is borne out by the fact that the order of the effects with different gases is very much the same as that found by J. J. Thomson for the relative frequency of occurrence of the corresponding negatively-charged atoms and molecules in positive rays. Even if the electronic emission were due to chemical action some such effect as the above would be necessary for the existence of any current at all at the high temperatures. If, however, chemical action were the determining factor, it would be expected that the effect with CO, would be of quite a different order from that with the other gases investigated. The experiments cannot therefore be held either to prove that the emission of electrons from hot carbon is an immediate consequence of chemical action between the carbon and the surrounding gases, or to invalidate those theories which regard this effect as a physical property of the hot solid. F. J. H.

1305. *Photoelectric and Photo-chemical Action.* O. W. Richardson. (Phil. Mag. 27. pp. 476-488, March, 1914. Paper read before the Amer. Physical Soc., Chicago, Nov., 1913.)—The experimental complexity of relations between number of emitted electrons and stimulating radiation makes advisable a wide basis for a theory of these actions, and an attempt is here made to develop such a theory on the basis of the energy abstracted from radiation in liberation of an electron or atom, and since argument is unaffected by existence of change the term "atom" may be taken to include ions and electrons. The fundamental equation obtained involves the assumption, as yet not tested experimentally, that the number of atoms emitted by a given amount of light is the same whether light is or is not decomposed, without energy loss, into its spectral constituents, which is the simplest assumption consistent with photoelectric evidence that the number of emitted electrons is simply proportional to the intensity of light of definite spectral composition, but varies greatly for equal energies and for different frequencies. It is also assumed that: the distribution of energy in the radiation is given by Planck's formula; that photo-chemical actions are fundamentally independent of temperature at low temperatures, as is indicated by the experimental evidence, and that they do not contravene the second law of thermodynamics; that the contribution of the radiation to the mean internal energy of the emitted atoms, *i.e.* their kinetic energy in the condensed form, is negligible. This last assumption is a very real restriction of the theory, which it makes essentially a provisional one, since the whole of the internal energy of the atoms might quite possibly arise from the radiation. The fundamental equation is then shown to lead to the conclusion that $\phi(\gamma) = h\gamma$, where h is Planck's constant, and $\phi(\gamma)$ is the mean energy which each atom, liberated under the influence of monochromatic radiation of frequency γ , has acquired from the radiation at the moment of liberation. It is then further shown that a consistent scheme of relations may be framed whereby this equation may hold good at all temperatures. In comparing the scheme so formulated with experiment it must be remembered that the neglect of the part played by electron reflection in the electrical case, and by corresponding atomic deflections in other types of photo-chemical action, although not affecting the equilibrium values, will affect photoelectric results dealing, not with a state of equilibrium, but with the rate of emission under a given illumination. G. W. DE T.

1306. *Influence of Occluded Gases on the Selective Photoelectric Effect.* R. Pohl and P. Pringsheim. (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 836-844, April 15, 1914.)—Potassium which had been boiled continuously for in one case 180 hours and in another 480 hours in an extremely good vacuum, whereby its yield of occluded hydrogen changed from 2 c.cm. to 4×10^{-4} c.cm. per hour per c.cm. of potassium, was found to give the same selective photoelectric effect to within the limits of experimental error as potassium not so treated. The presence of hydrogen in the metal does not therefore appear to be of prime importance. This result is in direct opposition to that obtained by Wiedemann and Hallwachs [see Abstract No. 722 (1914)], the cause of which the authors are unable to explain. A general discussion on the causes of the emission of electrons by short electromagnetic waves, by chemical action, and by heat and the possibility of connecting them is included. F. J. H.

1307. *Transmission of Kathode Rays through Matter.* R. Whiddington. (Roy. Soc., Proc. Ser. A. 89. pp. 554-560, March 2, 1914.)—Homogeneous kathode rays of known speed were allowed to fall on sheets of metal of various thicknesses and the fraction transmitted was determined. The results show that the law of Lenard stating that the absorption coefficient is connected with the speed by the relation $\lambda v^4 = \text{constant}$, is not generally true when λ is determined by the number of rays incident and transmitted. The alternative formula $\lambda = b/v^4 + c$ is shown to represent the facts more closely within certain limits of velocity. It appears that the lower limit of velocity, to which the formula is applicable, depends only on the thickness of the absorbing sheet. This provides a ready method of determining the constant a in the relation $v_0^4 - v_x^4 = ax$, which gives the variation in speed of the rays traversing the absorbing sheet [see Abstract 818 (1914)]. The results show that a/ρ is constant, where ρ is the density of the absorber. Except in the case of copper no definite effect of selective absorption could be observed when the speed of the kathode rays is just sufficient to excite the characteristic radiation of the material they traverse. E. M.

1308. *Phenomena in Rarefied Gases.* B. Baule. (Ann. d. Physik, 44. 1. pp. 145-176, April 28, 1914.)—The paper deals theoretically with (a) the abrupt change of temperature which exists at the surfaces of solids placed in a rarefied gas to establish a temperature gradient, (b) the analogous phenomenon of "surface slip" occurring in experiments on the viscosity of rarefied gases, (c) the thermal conductivity of strongly rarefied gases, and (d) the viscosity of the same. Treating the solid body placed in the gas as a cubical space lattice in which the molecules or atoms vibrate about the lattice points with a mean kinetic energy proportional to the absolute temperature of the body, the author first deduces expressions for the above quantities in terms of well-known constants for the gas and the distance apart of the molecules of the solid. The abrupt temperature change is found to be proportional to the temperature gradient in the gas and the surface slip proportional to the velocity gradient, both being inversely proportional to the pressure as is borne out by experiment. The calculated values are in excellent agreement with the experimental results of P. Lasareff [Abstract No. 892 (1912)] for the former and of A. Timiriazeff [Abstract No. 1246 (1918)] for the latter. The expressions previously arrived at by Smoluchowski for the abrupt temperature change and the surface slip are similar to those now obtained but involve unknown

constants; in the author's treatment these constants are connected with other well-known constants for the gas. Moreover, the simple connection which, according to Smoluchowski, exists between the constants for the two phenomena and which was found by Timiriazeff to break down completely in the case of hydrogen, is shown to be erroneous. In obtaining expressions for the thermal conductivity and the viscosity of highly rarefied gases the rarefaction is considered to be so great that the effects of the collisions of the molecules of the gas with one another are negligible in comparison with their collisions with the molecules of the solids in them. The values obtained for the thermal conductivities of H, O, and CO, are in good agreement with the values obtained experimentally by Knudsen [Abstract No. 899 (1911)].

F. J. H.

1309. *Alternate-current Discharge with Small Current between Metal Electrodes.* E. Merkel. (Ann. d. Physik, 48. 5. pp. 725-748, March 18, 1914. Extract from Dissertation, Göttingen, 1918.)—Guye and Monasch in measuring the p.d. across an alternating-current arc between metal electrodes, found that below a certain arc length the effective p.d. instead of falling began to increase and to show marked irregularities. The anomaly showed itself with all pure metals and with an arc length of from 0 to 8 mm. [see Abstract No. 917B (1904)]. The author finds that these irregularities are due to irregularities in the p.d. (a) required to start the arc and not to irregularities in the lower p.d., (b) which maintains the current during the remainder of the half-period of alternation. The irregularities may be removed by allowing ultra-violet light to fall on one electrode, but the p.d. (a) still shows an anomalous behaviour below a certain arc length. As the arc is reduced in length below 8 mm., the p.d. (a) rises instead of falling, until the arc length has been reduced to about 2 mm., when it falls again. The p.d. (b) is throughout proportional to the length of arc. The irregularity in (a) extends for a greater arc length in H than in air or CO₂. Diminishing the pressure also increases the range of the irregularity. (a) is, in general, higher in air than in H or CO₂. (b) is, in general, higher in H than in air or CO₂. (a) is affected by the material of the electrodes only in CO₂, whereas (b) is dependent to a considerable extent on the material of the electrodes. The form of the p.d. curve is obtained by an oscillograph.

T. P. B.

1310. *Striations in Pure Gases, and the Influence of Impurities.* P. Neubert. (Phys. Zeitschr. 15. pp. 480-488, May 1, 1914.)—The author has shown [Abstract No. 941 (1914)] that the striations in a discharge in hydrogen are modified considerably by the addition of traces of oxygen, which widens the limits of pressure within which striations are possible. He now shows that another electro-negative gas, namely iodine vapour, modifies the striations in hydrogen to a greater extent, and suggests that the greater the differences between the electrical properties of the gases, the more pronounced is the modification of the striations. He gives further illustrations of this view. Gehlhoff's discovery [Abstract No. 488 (1918)] that in very pure nitrogen and helium no striations are possible has been shown to apply also to pure oxygen, and to mercury-vapour. Even with slight traces of impurities, the unstriated discharge is still obtained. It was not possible to get an unstriated discharge in hydrogen, but this may be due to the difficulty of getting very pure hydrogen. With pure oxygen it was found that not only do the striations vanish, but for certain conditions [high p.d. between

the electrodes, 2 mm. Hg pressure and current densities of about 10 milliamps.] the discharge was absolutely dark. Adding hydrogen under these conditions gives the red discharge of hydrogen which shows only the hydrogen spectrum. J. R.

1311. *Oscillating Spark as an Economic Source of Ultra-violet Light.* J. de Kowalski. (Comptes Rendus, 158. pp. 1887-1889, May 11, 1914. Soc. Int. Elect., Bull. 4. Ser. 3. pp. 487-450, May, 1914.)—Experiments have been made with a view to obtaining the most suitable conditions for the production of ultra-violet light from the spark of an oscillatory circuit, and, in particular, of the "mean ultra-violet rays" used in sterilisation and photo-chemical reactions. It is found that the region of max. radiated energy is displaced towards the longer wave-lengths as the current in the oscillatory circuit is increased but towards the shorter wave-lengths the greater the amount of energy consumed in the spark; its position and intensity varies also with the nature of the electrodes. The intensity of the "mean ultra-violet rays" increases as the frequency of the oscillations decreases. If a resonance transformer is used as the source of the oscillations a definite relation can be obtained between the number of sparks per sec., the capacity, and the frequency of the primary current, and thus the most economic conditions of working can be obtained. F. J. H.

1312. *Continued Appearance of Gases in Vacuum Tubes.* G. Winchester. (Phys. Rev. 8. Ser. 2. pp. 287-294, April, 1914.)—The following facts are noticed in connection with the liberation of gases from chemically pure Al electrodes in discharge tubes by the application of large potentials from an induction coil:—(1) There is no relation between the amounts of gases thrown off and the size of the kathode. (2) The presence of hydrocarbons has no influence upon the amounts or kinds of gases evolved. (3) Hydrogen is evolved as long as any of the kathode remains. (4) Helium and neon are eliminated after a comparatively short time. Experimental curves in which pressure is plotted against time are given. These show that for the first few hours gas is evolved at a greater rate than subsequently, the rate of evolution finally assuming a steady value so long as the conditions remain steady. If the tube is rested or if the potential is increased or if the gas is quickly pumped out the rate of evolution increases for an hour or two, but finally assumes a steady value again. The author concludes that helium and neon are most probably occluded in the surface only, having been previously absorbed from the atmosphere. Hydrogen may possibly be a disintegration product of the metal in somewhat the same manner as the α -particle is disintegrated from radium, the hydrogen requiring the assistance of the large electric force to enable it to leave the metal. F. J. H.

1313. *Diffraction of Electric Waves Round a perfectly Reflecting Sphere.* H. M. Macdonald. (Roy. Soc., Proc. Ser. A. 90. pp. 50-61, April 1, 1914.)—In a previous paper [Abstract No. 609 (1910)] the author calculated the effect produced at a point P on a perfectly conducting sphere by a Hertzian oscillator placed outside the sphere, when the radius is large compared with the wave-lengths considered. The calculation failed for the case of the oscillator on the surface. A series is here obtained which converges rapidly for large values of θ , the angular distance of the point P, at a distance r from the centre of the sphere of radius a ($r > a$) from the oscillator. The accompanying table, in which λ is the earth's surface wave-length, and the second

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column gives the distance in miles of P from the oscillator, and $r=a$, shows the nature of the results obtained. The first term of the series only has been taken, the effect of the second and following terms being negligible except for the first three entries in the last column and the first entry in the preceding column, where the second place of decimals may possibly be affected. They confirm the remark in a recent paper by Rybczynski [Abstract No. 1499 (1918)] on the impossibility of representing the facts by a single exponential as the oscillator is approached.

θ .	Miles.	$\lambda =$ 320 metres.	$\lambda =$ 625 metres.	$\lambda =$ 1220 metres.	$\lambda =$ 2560 metres.	$\lambda =$ 5000 metres.
0 0						
6 0	419	0.18	0.84	0.54	0.80	1.04
6 20	442	0.15	0.80	0.49	0.74	0.98
6 40	465	0.13	0.26	0.44	0.69	0.93
7 0	489	0.11	0.22	0.40	0.64	0.88
7 20	512	0.09	0.19	0.36	0.59	0.83
7 40	535	0.07	0.17	0.32	0.55	0.78
8 0	559		0.15	0.29	0.50	0.73
8 20	582		0.13	0.26	0.46	0.69
8 40	605		0.11	0.23	0.43	0.65
9 0	628		0.09	0.21	0.39	0.61
9 20	652		0.08	0.18	0.36	0.57
9 40	675		0.07	0.16	0.33	0.53
10 0	698			0.14	0.30	0.50
10 20	721			0.13	0.28	0.47
10 40	745			0.11	0.26	0.44
11 0	768			0.10	0.24	0.41
11 20	791			0.09	0.22	0.38
11 40	814			0.08	0.20	0.36
12 0	837				0.18	0.34
12 20	861				0.16	0.32
12 40	884				0.15	0.30
13 0	907				0.14	0.28
13 20	931				0.13	0.26
13 40	954				0.12	0.24
14 0	977				0.11	0.23
14 20	1000				0.10	0.21
14 40	1024				0.09	0.20
15 0	1047				0.08	0.18
15 20	1070				0.08	0.17
15 40	1094					0.16
16 0	1117					0.15
16 20	1140					0.14
16 40	1164					0.13
17 0	1187					0.12
17 20	1210					0.11
17 40	1233					0.10
18 0	1257					0.10

G. W. DE T.

1314. *Induction-coil Potentials*. E. T. Jones. (Phil. Mag. 27. pp. 565-566, April, 1914).—The paper is a continuation of two former ones [see Abstracts Nos. 527 (1909), 578 (1912)]. In one of these the secondary voltage of two coupled oscillation circuits, t secs. after the primary is set oscillating, is given by the expression $A_1 e^{-k_1 t} \sin(2\pi n_1 t - \delta_1) - A_2 e^{-k_2 t} \sin(2\pi n_2 t - \delta_2)$, where n_1, n_2 are the frequencies of the two oscillations of the system and the other six constants can be calculated from the capacities, inductances, and resistances of the circuit. The paper describes tests on the application of the

theory to an 18-inch induction coil with three different condensers in the primary circuit. The various constants of the circuit are determined experimentally—where possible, in more than one way—and the calculated voltage is compared with that determined experimentally. An oscillograph is used to determine frequencies and secondary voltage. The experimental and theoretical values agree well and the theory given in the previous papers is thus shown to be sufficient for the calculation of the secondary potential and the most effective value of the primary condenser. The experimental results show that to about 4 % the secondary voltage is proportional to the primary current. No matter how rapid the break of the primary current, a certain amount of capacity across the break increases the length of the secondary spark. The most efficient value of the coupling of the two circuits is 0.756.

T. P. B.

1315. *Characteristic Curves and Sensitiveness Tests of Crystals and other Detectors.* P. R. Coursey. (Phys. Soc., Proc. 26. pp. 97-114; Discussion, pp. 114-116, Feb., 1914. Electrician, 78. p. 188, May 8, 1914. Abstract.)—The tests described in this paper were taken with a view to finding out whether the second differential of the characteristic curve bears any resemblance to the curve of sensitiveness to wireless signals, as is known to be the case for valve detectors of the Fleming type. A number of curves accompany the paper and these should be referred to.

H. H. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1316. *Dielectric Constants of Certain Highly-compressed Gases and the Mossotti-Clausius Relation.* A. Occhialini. (N. Cimento, 7. Ser. 6. pp. 106-126, Feb., 1914.)—Following on his work on air [Abstracts Nos. 1048, 1486 (1918)] the author has measured over wide intervals of pressure the dielectric constants of pure oxygen, hydrogen, and carbon dioxide. It is found that, under these conditions, the results obtained are not in agreement with the empirical relation, $(K - 1)/d = \text{constant}$ but accord very exactly with the Mossotti-Clausius formula, $(K - 1)/(K + 2)d = \text{constant}$, where K represents the dielectric constants and d the density of the gas. [See Abstract No. 588 (1918).]

T. H. P.

1317. *Absolute Measure of the Peltier-effect between Metals and Electrolytes.* G. Guglielmo. (Accad. Lincei, Atti, 28. pp. 498-499, April 5, 1914.)—The author has measured the Peltier-effect between a metal and an electrolyte by Jahn's method, which consists in measuring the separate amounts of heat evolved when a current is passed from the metal to the electrolyte and from the electrolyte to the metal. The Joule effect being the same in both cases, the difference between the two amounts of heat, when suitably corrected, represents twice the Peltier-effect. Measurements were made with plates of amalgamated zinc in a solution (density, 1.296 at 21.50°) of 148.5 gm. of crystallised zinc sulphate in 178.5 gm. of water. For the amount of heat evolved in the passage of the coulomb from the zinc to the solution, values varying from 85.5 to 60 milligramme-calories were obtained, the mean being 48.9. With a solution of zinc iodide containing 52 gm. of the salt to 202.5 gm. of water, and having the density 1.20 at 20°, the values ranged from 87 to 46.5 milligramme-calories, the mean being 42 milligramme-calories per coulomb.

T. H. P.

1318. *Electrical Condition of a Gold Surface during the Absorption of Gases and their Catalytic Combustion.* H. Hartley. (Roy. Soc., Proc. Ser. A. 90. pp. 61-68, April 1, 1914.)—A gauze of fine gold wire connected to an electrometer was suspended in a vessel which could be exhausted and heated to about 850° C. The voltage acquired by the gauze was measured, (a) while the combination of oxygen and hydrogen went on at its surface [see Abstract No. 1628 (1906)], (b) while H, O, or CO were being absorbed by the metal, and (c) while CO and O were combining at the surface to form CO₂. The author draws the following conclusions from his observations :—(1) A gold surface acquires a negative charge during the catalytic combustion of gases in contact with it. (2) This electrical effect is probably antecedent to the actual combustion, and is primarily due to occlusion. (3) The metal becomes negatively charged during the occlusion of the combustible gas (H or CO), and positively charged during the occlusion of O. (4) Such electrical effects are probably due to occluded gas which is leaving rather than entering the metal. Any cause, such as a sudden lowering of temperature, which would momentarily check the overflow of occluded gas, will likewise diminish the charge, or may even momentarily stop it altogether. Conversely, a sudden diminution of the gas pressure in the vicinity of the metal, which would increase the rate of outflow of the occluded gas from the metal, will temporarily increase the intensity of the electrical effect. (5) These temporary disturbances are probably due to the fact that a change in either temperature or pressure of the system is accompanied by a change in the dynamic equilibrium between the ingoing and outflowing gas. F. J. H.

1319. *Influence of Temperature on Electro-capillary Phenomena.* P. Kandidof. (Russian Physico-Chemical Soc., Journ. 45. [Physical Part] pp. 207-209, 1918.)—Within the limits of temperature, 17° and 65°, the variation of electro-capillarity is found to be less than 1 per cent., and is hence constant within the limits of experimental error. T. H. P.

1320. *Use of Radium for Lightning Conductor.* B. Szilard. (Comptes Rendus, 158. pp. 695-697, March 9, 1914.)—A disc coated with about 2 mgm. radium bromide is placed near a pointed rod and it is found that the ionisation produced helps to prevent a disruptive discharge. E. M.

1321. *Note on the use of the Wilson Tilted Electroscope.* H. W. Farwell. (Amer. Journ. Sci. 87. pp. 819-820, April, 1914.)—In using the tilted electroscope the author has noticed a lack of steadiness of the zero of the leaf. By placing a glow-lamp in various positions near the instrument he now shows that the fluctuations are due to convection currents within the electroscope case. Hence the necessity for adjusting the suspensions in a fair vacuum.

W. C. S. P.

1322. *Contact-electricity between Gases and Conducting and Non-conducting Fluids.* A. Coehn and H. Mozer. (Ann. d. Physik, 48. 7. pp. 1048-1078, April 2, 1914. From Dissertation, Göttingen, Feb., 1918.)—The object of the research here described was to determine whether the contact of gases with non-conducting liquids follows the law of charging found by Coehn [Abstract No. 145 (1910)] for dielectrics, and also what effect would be produced in the case of electrolytically conducting liquids. A method of investigation was employed of bubbling the gas through the liquid and measuring the resulting charge by means of a sensitive quadrant electrometer. The following are

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some of the results of the investigation :—(1) In the case of the contact of gases with non-conducting or slightly-conducting liquids the law of charging for dielectrics, that substances of higher dielectric constant become charged positively by contact with substances of lower dielectric constant, was established both for pure liquids and for solutions of non-conductors in water. (2) With solutions of electrolytes in water the negative charge of the gas and the corresponding positive charge of the liquid decrease with increased concentration, and for a certain concentration a reversal point is reached beyond which the gas acquires a positive charge. (8) The reversal point was investigated for a number of electrolytes with various anions and kathions by bubbling through them oxygen and hydrogen. It was found that with acids the reversal point was given by much smaller concentrations than with neutral salts or alkalis. (4) The question whether the null charge at the reversal point corresponds to the existence of no charged carriers, or to the presence of equal numbers of positive and negative carriers was also dealt with. For all liquid non-conductors, including pure liquids as well as solutions of non-conductors in water, only negative carriers can be produced in the gas. In the case of electrolytes the positive carriers increase with increased concentration till at the null point both positive and negative carriers exist in equal numbers.

A. W.

1323. Measurement of Capacity by a Guard-ring Condenser. G. Hoffmann. (Phys. Zeitschr. 15. pp. 860-861, April 1, 1914.)—The author advocates the use of the guard-ring condenser for the measurement of the absolute capacity of an electrometer and its accompanying apparatus. He describes and illustrates the form of condenser used. In the calculation, let the suffix a refer to the unguarded plate of the condenser, i to that plate which is connected with the electrometer, etc., o to all the other conductors present, then the charge on the plate i is given by $e_i = C_{ia}V_i + C_{io}V_o + C_{io}V_a$, with the usual notation. C_{ia} is known from the dimensions of the apparatus, V_o is made zero, e_i is kept constant during an experiment, hence a change in V_a of V'_a produces the effect in i of an additional charge $-C_{ia}V'_a$. By altering the potential of the plate a the electrometer may thus be calibrated for electric charge. If the electrometer has already been calibrated for potential its "working" capacity may be found from the formula $C_w = -C_{ia}V'_a/V'_i$, where V'_i is the change of reading produced by a change of V'_a in the potential of the plate a .

J. W. T. W.

1324. Determination of Electromotive Force of Weston Normal Cell in Semi-absolute Volts. A. N. Shaw and H. L. Callendar. (Roy. Soc., Phil. Trans. 214. pp. 147-198, May 12, 1914.)—This paper presents the result of an absolute determination of current performed with the aid of a modified form of bifilar Weber electro-dynamometer. The former obstacles to a precise use of this type of instrument have been overcome and it is claimed that the absolute accuracy of the value of the e.m.f. of the Weston normal cell has been increased by this investigation. The paper deals with the general theory of the instrument and its construction, the calculation of the dynamometer constants and the determination of the e.m.f. of standard cells. The theory and method of measuring the mean radius of the small coils by electromagnetic comparison with the large coils was one of the most difficult parts of the investigation and nearly 400 observations for various quantities are involved in the final mean. It is thought that an accuracy of 1 part in 100,000 is obtained. The standard resistances were compared with the

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standards in the Bureau of Standards at Washington and the standard cells were compared with cells at Washington in 1908 and 1909, and with those at the National Physical Laboratory in 1909 and 1912. The value given for the e.m.f. of the Weston normal cell is 1.01881 semi-absolute volts at 20° C.

F. E. S.

1325. Comparison of nearly equal Electrical Resistances. G. F. C. Searle. (Cambridge Phil. Soc., Proc. 17. No. 4. pp. 840-850, Jan. 80, 1914.)—The best known method of determining the ratio of the resistances of two nearly equal coils is that of Carey Foster in which the difference of the resistances is expressed as the resistance of a measured length of graduated wire. In recent years this method has been abandoned for comparisons of the highest precision and a method of shunting is now employed. The great advantage of the method of shunting is that instead of dealing with the resistance of 1 or 2 mm. of the wire of the bridge, we have to deal with shunting resistances measured by many hundreds of thousands of ohms. The general theory of the method is given and this is followed by some practical details of measurements made in the Cavendish Laboratory. The paper should prove useful to teachers.

F. E. S.

1326. Kathode-ray Oscillograph. A. Dufour. (Comptes Rendus, 158. pp. 1389-1341, May 11, 1914.)—A modification of the ordinary Braun-tube oscillograph is described which is designed for the purpose of recording photographically variable currents which are not periodic. The fluorescent screen is dispensed with, and the bundle of kathode rays allowed to impinge directly on the photographic plate. By the application of an alternating field of frequency 10,000 obtained by means of a singing arc the impression on the plate is drawn out into a straight line. A direct field is now applied at right angles to the first, and its intensity caused to change abruptly, the duration of the change being of the order of a thousandth of a second. In this way a sinusoidal curve is traced which gives a time scale. The phenomenon to be studied is then allowed to act in such a way that the variable deviation is produced in a direction at right angles to the original straight line. A sensitiveness of 1 mm. per one three-millionth of a second is obtained. The author contemplates using this method for studying the form of currents in aërials and detectors of various kinds.

For the production of the kathode rays a large electrostatic machine is found to be the most satisfactory.

F. J. H.

1327. Vibration Galvanometers of Low Effective Resistance. A. Campbell. (Phys. Soc., Proc. 26. pp. 120-126, Feb., 1914.)—The author gives the mathematical theory of the moving-coil vibration galvanometer, and obtains simple relations between the two resonance frequencies: the free frequency and the amplitude time constants [see Abstract No. 1877 (1918)]. It is also shown how all the constants of the equation of motion can be deduced from observations of the direct- and alternating-current sensitivities, the alternating voltage sensitivity, and the "dead" resistance. Complete results of tests on a number of coils are given, unifilar suspensions of phosphor-bronze strip being used in all cases. The number of turns was varied from 1 to 40. The current sensitivities ranged from 6 mm. to 160 mm. per microamp. at 1 m. and at 100 \sim per sec., the corresponding effective resistances being about 9 ohms and 1500 ohms respectively. It is seen that it is possible to obtain good current sensitivity with coils having effective resistances as low as 80 or 40 ohms.

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It is also pointed out that the selectiveness (for given current) due to resonance is mainly determined by the absolute value of the "amplitude time constant": the more sluggish a galvanometer is in settling to zero the more selective will it be. In the *discussion*, G. W. O. Howe pointed out that the method adopted by the author was similar to that of finding the no-load losses and efficiency of a motor by cutting off the supply and observing the rate of slowing down. W. C. S. P.

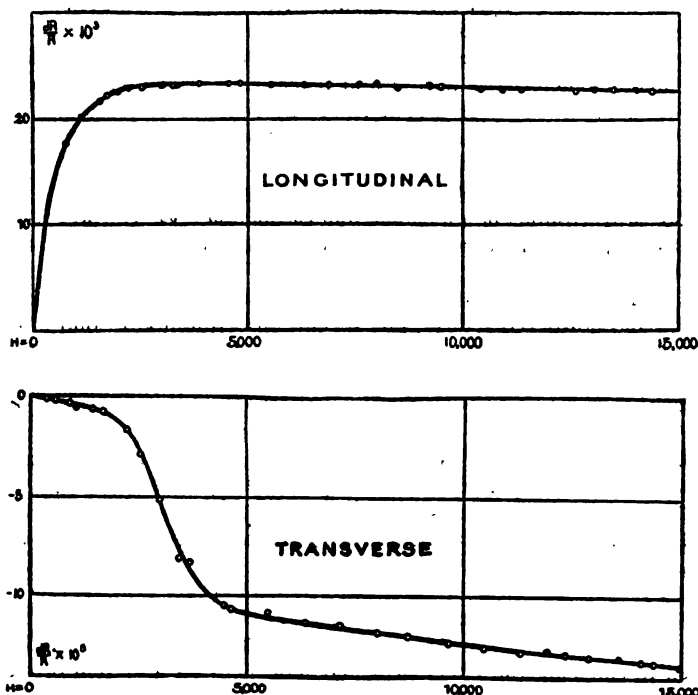
ALTERNATING CURRENTS AND MAGNETISM.

1328. *Effect of Iron upon a Sinusoidal Current.* E. Marini. (N. Cimento, 7. Ser. 6. pp. 5-10, Jan., 1914.)—The method of the Braun-tube is used, the circuit containing the iron producing an harmonic displacement of the spot. A circuit in parallel with this, but not containing iron, is arranged to produce an equal and opposite displacement of the spot. Thus the fundamental term is annulled and only the harmonics due to the iron are present, any displacement being due to them. Only one term is of importance, and in the case measured in which this was greatest it amounted to 8.5 per cent. of the amplitude of the fundamental. S. G. S.

1329. *Change in Electrical Resistance of the Heusler Alloys when placed in a Transverse Magnetic Field.* O. Bonazzi. (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 815-819, April 15, 1914.)—The author suggests that in order to obtain a simple explanation of the magnetic properties of the Heusler alloys some of the other phenomena exhibited by them should be carefully studied. He investigates the change in resistance of a non-inductive spiral of the alloy, 0.1 mm. diam. when placed in a transverse magnetic field which can be varied up to 80,000 gauss. The resistance of this particular Cu-Mn-Al alloy is found to decrease with increase in the field, and is thus similar to ferromagnetic materials. At the highest field the decrease in the rate of change of resistance shows the approach of a saturation effect. W. C. S. P.

1330. *Iron Shielded from Earth's Magnetism.* E. Wilson. (Roy. Soc., Proc. Ser. A. 90. pp. 179-188, May 1, 1914.)—Experiments were made on a ring specimen of stalloy built up from stampings, and a magnetic shield was formed from stampings of transformer iron. The specimen was supported symmetrically within the shield, and the common axis placed at right angles to the magnetic meridian. Measurements taken ballistically with the ring shielded and unshielded show that the earth's magnetism may seriously affect the magnetisability of iron. Comparing the results obtained when stalloy was magnetised and then demagnetised, with the results of similar experiments on the same material demagnetised but exposed to the earth's magnetism, the ratio of the permeabilities had a maximum of 1.79 when B was 172, and the ratio of the maximum permeabilities was 1.24. The maximum μ for the shielded specimen was 5900. The dissipation of energy by hysteresis was less when the stalloy was demagnetised in the shield than when demagnetised and then exposed to the earth's magnetism. The Steinmetz index, after rising to a maximum of about 8 for a force of about 0.008 c.g.s., begins to diminish as the force is reduced, and at about this point the hysteresis loops tend to become parallel straight lines. [See also Abstract No. 1161 (1908).] G. E. A.

1331. *Electrical Resistance of Nickel in Magnetic Fields.* W. M. Jones and J. E. Malam. (Phil. Mag. 27. pp. 649-659, April, 1914.)—The experiments were undertaken to throw some light on the discrepancy between the results for the longitudinal effect obtained by Owen and Heaps [see Abstracts Nos. 519 (1911) and 574 (1912)]. The slide-wire bridge method was used in conjunction with an instrument by means of which the difficulty of accurately setting the specimen in the field of the electromagnet is



obviated. A series of curves, in which dR/R is plotted against H for various settings of the specimen at or near the transverse position, indicates that an error of setting of $2\frac{1}{2}^\circ$ will give the results of Grunmach and Heaps [see Abstract No. 115 (1907)]. Another series of curves shows the change of the effect with the orientation of the specimen. The two extreme curves for the longitudinal and transverse positions (see Figs.) are given on a larger scale. The change of resistance in the former case attains a maximum in a field of about 8000 c.g.s.

G. E. A.

1332. *Change of Length in Nickel in Alternating Fields.* W. Browne. (Roy. Dublin Soc., Proc. 14. 21. pp. 297-301, May, 1914.)—From observations of a soft nickel wire, 226 cm. in effective length, subjected to low alternating fields while sustaining a small longitudinal load, it was found that the contraction for the alternating fields was greater than that for the direct fields by about 68 per cent. for the smallest load (0.1184×10^5 gm.), and by 44 per cent. for the largest load (10^5 gm.). Neglecting values for low fields, the a.c. contraction is nearly in a constant ratio to the d.c. contraction, the ratio varying with the load.

G. E. A.

1333. Measurement of High Inductions by Yoke Method. E. Gumlich. (Deutsch. Phys. Gesell., Verh. 16. 9. pp. 395-405, May 15, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—Details are given of a simplified apparatus for testing bars or bundles of strips by means of the bar- and-yoke method in fields up to 7500 gauss. An example of a test shows that the results agree well with those given by a modified isthmus method previously described. [See Abstract No. 1756 (1909).] G. E. A.

1334. Astatization Device for Magnetometers. E. Gumlich. (Deutsch. Phys. Gesell., Verh. 16. 9. pp. 406-410, May 15, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—In order to increase the sensitiveness of the magnetometer, the needle and its case are placed within a gap in a coil wound in the form of a split ring. Currents of variable strength can be sent round the coil so as to produce a local magnetic field at the needle, and thus to partly neutralise the earth's directing force. G. E. A.

1335. Magnetisation of Manganese and Chromium. W. Lepke. (Deutsch. Phys. Gesell., Verh. 16. 8. pp. 869-882, April 30, 1914. Extract from Inaug. Dissertation, Marburg, 1918.)—In continuation of Ihde's research [see Abstract No. 1781 (1918)], the max. susceptibility of Mn and of Cr was determined in the solid and powdered states. The specific susceptibility of solid Mn and Cr increases with the field to a maximum in a field of about 1100 gauss, thereafter diminishing as the field increases. Manganese has a max. value of 10.6×10^{-6} , and Cr 4.1×10^{-6} . In a field of 18.9 kilogauss the respective values become 9.4×10^{-6} and 8.5×10^{-6} . These metals have a higher susceptibility in the powdered state than when solid, especially when pulverised to a fine dust. The increase of 100 per cent. in susceptibility found by Ihde was not confirmed, the observed increases being 15 per cent. for Mn and 50 per cent. for Cr. It is very probable that the difference in susceptibility in the two states disappears in very high fields. G. E. A.

1336. Contribution to Statistic Electronic Theory of Magnetism. E. Holm. (Ann. d. Physik, 42. 2. pp. 241-256, May 12, 1914.)—Statistical methods are applied to calculate the effect of a magnetic field on a system of electrons acted on by central forces proportional to the distance. The result, which is opposed to the recent conclusions of Kroo but agrees with the older results obtained by Voigt and J. J. Thomson by non-statistical methods, is that the field causes no magnetisation of electrons. G. E. A.

1337. Magnetic Susceptibility of Water. H. C. Hayes. (Phys. Rev. 8. Ser. 2. pp. 295-305, April, 1914.)—The methods of measuring the above quantity are classed as those of Faraday, Quincke, and Wills, and the determinations of it from 1855 onwards are tabulated. The chief experimental difficulty in using Faraday's method was overcome by means of a device for placing the specimen at the point for which dH/ds had been accurately determined. The value of the susceptibility of a specimen consisting of 0.150 gm. of distilled water at 24°C. was -7.26×10^{-7} , which agrees well with the recent determinations of Sève, de Haas and Drapier, and Weiss and Piccard [see Abstracts Nos. 1890 (1912) ; 518, 874 (1918)]. G. E. A.

1338. Theory of the Electromagnetic Field in Ferromagnetic Metals. W. Arkadief. (Russian Physico-Chemical Soc., Journ. [Physical Part] 45. pp. 812-844, 1914.)—The theory previously outlined [see Abstract No. 568 VOL. XVII.—A.—1914.

(1914)] is here developed in more extended form and illustrated by theoretical curves, which show (1) the course of the magnetic permeability or magnetic conductivity for different values of the damping of the primary magnet; (2) the variation of the refractive coefficient n , or the absorption coefficient k , for different values of the damping; (3) the electromagnetic spectra for certain metals, these representing the behaviour of the metals for different periods of the electromagnetic alternating field. Indications are obtained of two sharply separated regions of electronic and molecular characteristics of matter, corresponding with the divergences from Maxwell's classical theory and showing the limits of validity of this theory.

T. H. P.

1339. *Magneto-chemistry of Nickel Compounds and the Magnetron Theory.* B. Cabrera, E. Moles, and J. Guzman. (Archives des Sciences, 87. pp. 824-884, April, 1914.)—The authors have investigated the magnetic susceptibilities of solutions of nickel sulphate, chloride, and nitrate, and of nickel potassium cyanide, all the salts used being chemically and spectroscopically free from cobalt and iron. The results obtained confirm Koenigsberger's conclusion [Abstract No. 824 (1899)] that Wiedemann's law is applicable in all cases. According to Finke's results [Abstract No. 445 (1910)] it seems almost certain that with nickel sulphate, chloride and nitrate, and probably with all salts yielding the kathion Ni, in solutions of all concentrations and perhaps also in the solid salt, the number of magnetons is constant and equal to 16. Assuming the invariability of the number of magnetons in all nickel solutions, the salts studied furnish solutions of widely varying susceptibility, the absolute value of which can be calculated. With the chloride, which is the most soluble, the formula $[38.91m - 0.719(1-m)]10^{-8} - 11.7m(t - 20)10^{-8}$, gives the value of χ for a solution containing m gm. of the salt per gm. of solution at t° , which must be in the neighbourhood of 20° , the errors not exceeding about 0.5 per cent. If an accuracy of not more than 1 per cent. is desired, the values of m may be deduced from the quantity of dissolved salt, but more exact results, true to within 0.1 per cent. in the case of concentrated solutions, may be obtained by calculating the value of m from the empirical formula, $m = 1.057(D_s - D_w)_{15^\circ} - 0.551(D_s - D_w)^{1/2}_{15^\circ}$, where D_s and D_w are the densities of the solution and of water.

T. H. P.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1340. *New Apparatus for measuring the Intensity of the Röntgen Rays.* Furslenau's Intensimeter. (Archives d'El. Médicale, 22. pp. 489-492, May 10, 1914.) Immelmann. (Ibid. pp. 512-518, May 10, 1914. Paper read before the 10. Congrès de la Soc. Allemande de Röntgen.)—The apparatus consists of a selenium receiver and a galvanometer with battery in circuit. The Röntgen rays impinging on the receiver which is placed directly on the skin being radiated, produce a modification in the conductivity of the selenium and, consequently, a displacement of the galvanometer needle. The scale of the galvanometer is graduated in absolute units so that the dose per unit of time can be read directly both for superficial and deep applications.

A. E. G.

1341. *Criticism of Dose-meters in Actual Use.* Grossmann. (Archives d'El. Médicale, 22. pp. 511-512, May 10, 1914. Paper read before the 10. Congrès de la Soc. Allemande de Röntgen.)—In the dose-meters a fraction of the Röntgen rays is transformed in some cases into chemical energy, in

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others into physical energy other than that of the Röntgen rays. If these modifications are to represent an exact measure of the superficial dose of the rays which impinge on the skin, they ought to fulfil the three following conditions: (1) The dose absorbed by the dose-meter, for a homogeneous radiation of no matter what hardness, and, consequently, for a complex radiation of no matter what composition, ought to be proportional to the superficial dose absorbed by the skin. (2) It is necessary always that the same fraction of the dose absorbed by the dose-meter may be transformed into chemical or physical energy and thus measured. (3) The modifications produced in the dose-meter should represent an exact measure of this energy. It has been proved that only substances of atomic weight less than 24 do not emit a characteristic secondary radiation and present for that a regular absorption for all degrees of hardness. In the ionometer air is the substance used, and the elements composing it have atomic weights of 14 to 16. Sabouraud's pastille contains Ba, Pt, C, N, O, and H: the four last may be neglected, Pt has a regular absorption for all degrees of hardness of importance in radio-therapeutics, but with Ba a quick augmentation of the coefficient of absorption takes place for hard rays. Consequently this pastille is not exact for these rays. The photographic paper of Kienböck contains Ag, Cl, and Br. The silver is the most important of these components, for, in its case, a sudden increase of absorption occurs for hard rays. Hence it may be stated that the ionometer is the most exact dose-meter, Sabouraud's pastille takes second place, while Kienböck's paper is the least reliable.

A. E. G.

1342. *Comparison of some Radio Dose-meters.* Lévy-Dorn. (Archives d'Él. Médicale, 22. pp. 518-514, with Discussion, May 10, 1914. Paper read before the 10. Congrès de Soc. Allemande de Röntgen.)—A table is given showing the relations between the indications of a Sabouraud radiometer and those of the Kienböck quantimeter for degrees of hardness varying from 3-4 to 6-7 degrees Benoist. In the discussion, H. E. Schmidt made the statement that Kienböck's quantimeter is absolutely useless in practice, and this statement was corroborated by others.

A. E. G.

1343. *The Coefficient of Protection of Substances containing Caoutchouc.* B. Walter. (Archives d'Él. Médicale, 22. p. 510, May 10, 1914. Paper read before the 10. Congrès de Soc. Allemande de Röntgen.)—Taking the coefficient of protection of lead as 1, then that of caoutchouc with lead is 0.79 to 0.88, while lead glass has a coefficient of 0.80 to 0.54. Certain samples of caoutchouc with lead are found to be conductors for high-tension currents.

A. E. G.

1344. *Local Application of Radium in Therapeutics.* J. Joly. (Roy. Dublin Soc., Proc. 14. 20. pp. 290-296, May, 1914.)—Discusses the best forms of applicators for various cases with special reference to the amounts of β - and γ -radiation transmitted by screens of different thicknesses.

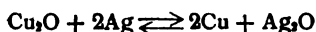
E. M.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1345. *Thermochemistry and the Periodic Law. Heats of Combination Linear Functions of the Atomic Weights of Related Elements.* W. G. MIXTER. (Amer. Journ. Sci. 87. pp. 519-584, June, 1914.)—The author discusses and represents graphically the relation between heat of formation of the oxides and chlorides of the elements, and shows the periodicity of the same, the heat of formation being a linear function of the atomic weight. Variation from linearity in certain cases is uniform. A. F.

1346. *Alloys of Gold with Arsenic.* A. P. SCHLEICHER. (Int. Zeitschr. Metallog. 6. pp. 18-22, March, 1914.)—Alloys of gold and arsenic have been prepared by fusing together the components and pouring the molten mass into water. The alloys thus obtained are very brittle, and show a grey fracture. Thermal analysis of the alloys containing between 100 and 74.58 atomic per cent. of gold gives the eutectic point as 665° and the corresponding As-content as 46-47 atomic per cent. Micrographic investigation gives confirmatory results. T. H. P.

1347. *Silver and Cuprous Oxide.* C. H. MATHEWSON and C. H. STOKESBURY. (Int. Zeitschr. Metallog. 5. pp. 198-212, Feb., 1914.)—It is shown that cuprous oxide dissolves freely in molten silver, but is practically insoluble in the solid metal. The thermal characteristics and the microstructure of alloys containing up to 20 per cent. Cu_2O are described. Within this range the alloys are similar to those exhibited by the system $\text{Cu}-\text{Cu}_2\text{O}$ (Heyn, Zeitschr. Anorg. Chem. 89. p. 1, 1904). Practically identical structures are obtained in the two eutectic mixtures, $\text{Cu } 98.5-\text{Cu}_2\text{O } 8.5$ and $\text{Ag } 98.7-\text{Cu}_2\text{O } 1.3$. The freezing-point of silver is lowered by 16 to 17 deg. by this eutectic proportion of Cu_2O . In all cases the calculated primary freezing-points of the silver are considerably higher than the observed values. This indicates that the dissolved cuprous oxide dissociates or reacts chemically with the solvent so as to increase the number of dissolved molecules. If the equation—



represents this reaction, approximately one-quarter of the cuprous oxide added is replaced by copper and silver oxide in these dilute metallic solutions. When a silver-copper alloy containing relatively little copper is melted and solidified with free access of air, the copper occurs as oxide between the polygonal grains of silver. C. O. B.

1348. *Variation of the Resilience of the Industrial Alloys of Copper as a Function of the Temperature.* L. GUILLET and V. BERNARD. (Comptes Rendus, 167. pp. 548-550, Oct. 6, 1918.)—The earlier work of the authors [Abstract No. 1581 (1918)] has been extended to brasses richer in zinc, to bronzes containing up to 20 % Sn, and to an alloy containing 1.4 % Zn and 2.4 % Al. Plotted in the form of temperature-resilience curves the results confirm the earlier observation on the unfavourable effect of lead. The Al bronzes rapidly lose resilience as the temperature rises

the value falling from 25 to 9 kg.-cm.² between 0° and 800°C. In the high-Sn bronzes the resilience is largely a function of the copper-content. Up to 12 % Sn the bronzes show a rapid drop in resilience in the neighbourhood of 200°C. Substitution of part of the tin by lead and zinc causes a lowering of the resilience particularly noticeable at low temperatures.

F. C. A. H. L.

1349. *Sound Ingots*. R. Hadfield. (Amer. Inst. Mining Engin., Bull. 88. pp. 557-576, April, 1914.)—The author describes and illustrates a number of ingots made by his process [Abstract No. 277 (1918)] in comparison with steel ingots cast by ordinary methods. Ingots cast by the process give a saleable product of at least 88 per cent. and sometimes as high as 95 per cent., while the steel produced is remarkably free from segregation. By a superficial examination it is possible to tell whether the ingot is sound or not. If there is a large cavity in the feeding head the ingot proper is free from honeycombs, blowholes, pipe, and segregation. Special experiments have shown that during solidification about 4 per cent. of the steel in the body of the ingot is drawn from the feeding head.

F. C. A. H. L.

1350. *Contribution to the Study of Cementation by Gases*. F. Kurek. (Stahl und Eisen, 82. p. 1780, 1914. Rev. de Métallurgie, 11. pp. 160-162, March, 1914. Extract.)—Bars of steel containing 0.09 % and 0.82 % Mn have been heated at various temperatures in CO, methane, and illuminating gas. The progress of carbonisation in CO was observed by determining the quantity of CO₂ in the issuing gases. Carbon monoxide gives a case which never attains the eutectic composition. Methane does not commence to carbonise below 800°C., but above 900°C. carbonisation is rapid and the resulting case high in carbon, e.g. at 1000°C. the outer layer took up 1.81 % carbon. Addition of ammonia reduces the carbonising power of both these gases. Illuminating gas begins to carbonise at 800°C. and has a more rapid effect than methane, giving in addition a more highly carbonised case.

F. C. A. H. L.

1351. *Hardness of Metals*. J. H. Andrew. (Int. Zeitschr. Metallog. 6. pp. 80-48, March, 1914.)—The author summarises the views of Edwards and Grenet on this subject and points out that in several respects the ideas are opposed. Brinell hardness tests on quenched and slowly cooled Cu-Al and Cu-Sn alloys showed that quenching actually softens some of the alloys. This proves that Edwards' theory stating that "any alloy retained as a homogeneous solution which would otherwise consist of two constituents is thereby rendered much harder," does not hold good in all cases. Consideration is then given to the particular case of iron-carbon alloys which differ from the Cu-Al alloys under discussion in that the phases separating at 700°C. are a pure metal (ferrite) and a pure metallic compound (cementite), while in the Cu-Al alloys the phases separating at 570°C. are two homogeneous solid solutions. Further, one of the constituents separating from the iron-carbon alloys at the inversion point, undergoes an allotropic change at the same temperature. In the light of Benedicks' theory austenite consists of a solid solution of carbon or carbide of iron in γ -iron, while martensite is a solid solution of carbon or cementite in a solution of α - and γ -irons. The author believes martensite to be made up of free cementite embedded in a matrix of undecomposed austenite and α -iron, the latter accounting for the magnetic properties of hardened steel, while the hardness is due to the combined effect of the

solid solution and the carbide. Alloys of iron and carbon do not appear to fall into line with the non-ferrous alloys in any generalisation on the property of hardness.

F. C. A. H. L.

1352. Volume of Molecules and of the Component Atoms. J. D. van der Waals. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 880-890, March 26, 1914.)—Taking into account the fact that the factor b of van der Waals' equation becomes less than 4 times the volume of the molecules when the volume decreases to almost $2b$, as it does for the critical state, the following relation holds approximately: $T_c/p_c = 7 \times 278b_c/(1 + a)(1 - b)$. If the factor 7 were equally great for all substances, the ratio T_c/p_c would be nearly proportional to the size of the molecules, and as the author's calculations are only of a preliminary character, this is actually assumed to be the case. For the different members of several homologous series of organic compounds, calculations are made from the critical data of the values of T_c/p_c ; similar calculations are also made for the constituent atoms of carbon, hydrogen, etc. The results obtained show that for normal compounds, that is, those which do not associate or dissociate under the critical conditions, the volume of the molecule is equal to the sum of the volumes of the component atoms. The volume of an atom is not, however, constant, but depends on the atoms to which, and the manner in which, it is bound. Thus, when united with others, atoms behave, as it were, as soft bodies, which can vary in both size and shape. An explanation of this is given by the conception that an atom is an orbit of electrons round a rigid centre formed by a point in which the atomic weight is concentrated or, when the atom is bi-, tri-, or tetra-valent, by 2, 3, or 4 orbits round centres in which one-half, one-third, or one-fourth of the atomic weight is concentrated. In this way the modification of the size in case of mutual binding may possibly be determined.

With benzene and other cyclic compounds the values of the above ratio are decidedly smaller than those calculated additively from the constituent atoms and comparison of the values for benzene and naphthalene leads to the conclusion that the smallness is to be ascribed not to the hydrogen atoms but to the carbon atoms.

T. H. P.

1353. Ozone Formation at Different Pressures. H. v. Wartenberg and L. Mair. (Zeitschr. Elektrochem. 19. pp. 879-881, Nov. 15, 1918.)—The experiments were made with a tubular apparatus, an outer tube of gilt brass and an inner tube of silvered glass, the oxygen entering and leaving through capillary tubes. The distance between the two electrodes was 2 or 6 mm., and the flow of gas was so regulated that the oxygen particles were exposed to the action of the field (1 milliamp. or less, up to 28,000 volts, 50 \sim) for equal times, mostly 5 minutes. The pressure varied between 0.5 and 5 atmos., and it was found that both the ozone concentration and the ozone yield (in mgm. of O_3 per watt-second) had a decided maximum between 0.5 and 1 atmo.

H. B.

1354. Solubility of Gases in Liquids. M. Kofler. (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1461-1472, July, 1918.)—The view has been advanced that the solubility of gases depends on the magnitude of the intermolecular spaces in a liquid. There is a marked parallelism between solubility and compressibility on comparing (1) a given solvent at different temperatures, (2) different solvents at the same temperature, (3) aqueous salt solutions, (4) aqueous sulphuric acid. The solubility-temperature curves for hydrogen and

helium in water pass through a minimum, which also appears in the compressibility-temperature curve for this solvent. There appears also to be a relationship between solvent power for gases and dielectric constant, since the true volume occupied in a liquid may be expressed by the formula $V = (K - 1)(K + 2)$. Finally the solubility appears to be influenced by the critical temperature of the dissolved gas; thus, all gases having a low critical temperature are sparingly soluble in water; again a fairly regular curve can be obtained by plotting $\log \alpha$ (α = solubility at 0° C.) against the "corresponding temperature," T/T_b , of the freezing-point of water relatively to the critical temperature of the gas. T. M. L.

1355. *Conductance and Viscosity of Electrolytic Solutions.* C. A. Kraus. (Amer. Chem. Soc., Journ. 86, pp. 85-86, Jan., 1914.)—In the case of aqueous solutions exhibiting negative viscosity, the conductance may be corrected for viscosity by a proportional factor; this is probably true also for alteration of viscosity by external pressure. But when the viscosity is greater than that of water, the conductivity diminishes less quickly than the fluidity; a correction may perhaps be made by considering the effect of viscosity on the individual ions. The influence of viscosity on the transference numbers is due to the unequal effects of viscosity on the two ions, depending largely on the relative sizes of the ions and of the molecules of the solute. The influence of rise of temperature is to equalise the speeds of the different ions, indicating that the ions approximate to equal sizes; but the unusual view is adopted that this effect depends on increasing size of the smaller ions due to increasing hydration, instead of to loss of water by the larger ions. No support could be found for the view that the exceptional velocity of hydrogen and hydroxyl is related to the fact that they are the ions of the solvent water. In non-aqueous solutions the speed of the ions changes far less than the fluidity, and in many cases no correction is needed up to normal concentration. T. M. L.

1356. *Intermiscibility of Liquids.* J. Holmes. (Chem. Soc., Journ. 108, pp. 2147-2166, Dec., 1918.)—The author has a method of determining molecular complexity from the changes of volume which occur on mixing two liquids. He concludes (in opposition to evidence derived from almost all other sources) that carbon disulphide is four times more complex than ethyl ether, and that esters such as ethyl tartrate are four times less complex. The paper contains, however, a large number of accurate measurements of the densities of liquid mixtures, and discloses in the case of mixtures of chloroform and amylalcohol a contraction on mixing which increases to a maximum, then diminishes and changes to an expansion, which in turn increases to a maximum and then decreases again. In the case of chloroform and acetone also there is a change from an expansion to a contraction, although the second maximum was not quite reached within the range of the measurements made. T. M. L.

1357. *Determination of Viscosity.* M. P. Applebey. (Chem. Soc., Journ. 108, pp. 2167-2171, Dec., 1918.)—In reply to criticisms by Bingham [Abstract No. 1751 (1918)] the author defends the method of expressing viscosities relatively to water, rather than in absolute units. Thus in his experiments the variations in the relative viscosities were only 0.009 %, where the absolute values of Bingham and White varied by 0.07 % and differed from those of Thorpe and Rodger by 0.6 %. Reduction to absolute units therefore introduces errors far larger than those occurring in relative measurements of the viscosity of solutions.

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In making relative measurements it is possible to use a capillary tube which tapers at the ends. This is a real advantage in securing uniform flow and preventing eddies, but has to be sacrificed when absolute measurements are made. Some additional hints are given for securing constancy of experimental conditions.

T. M. L.

1358. *The Water-gas Equilibrium in Hydrocarbon Flames.* G. W. Andrew. (Chem. Soc., Journ. 105. pp. 444-456, Feb., 1914.)—The author has studied the water-gas equilibrium by firing various mixtures of methane, ethane, ethylene, and acetylene with oxygen, and determining the composition of the gas mixture produced. In all cases the value of $K = C_{CO} \times C_{H_2O} / C_{CO_2} \times C_{H_2}$, was nearly constant, and nearly independent of the max. flame temperature. It is therefore argued that the experimentally determined constant probably does not correspond with the max. flame temperature but is characteristic of some hypothetical temperature, the equilibrium condition at which corresponds with the integration of the chemical changes which occur in a rapidly cooling mixture from higher to atmospheric temperatures. The hypothetical temperature corresponds to between 1500-1600°. It thus appears that the reaction $CO + H_2O \rightleftharpoons CO_2 + H_2$ proceeds with great rapidity during cooling. Although practically the same value was obtained for K in the above experiments, the author considers that secondary reactions play an important rôle.

A. F.

1359. *Limits of Visibility of Precipitates.* L. Rolla. (N. Cimento, 6. Ser. 6. pp. 249-254, Oct., 1918.)—The solubilities of AgCl, AgBr, and AgI, determined electrochemically, are found to be 1.2×10^{-5} , 5.0×10^{-7} , and 1.0×10^{-8} respectively. By means of the ultramicroscope estimations were made of the concentrations of silver nitrate which just gave visible precipitates with the chlorides, bromides, and iodides of sodium and potassium. With the three types of salts, the visibility begins at $0.9-1.5 \times 10^{-5}$, 4.5×10^{-7} , and $0.8-1.0 \times 10^{-8}$ respectively, these values all agreeing with those given by the electrochemical method. The ultramicroscope gives for the solubility of HgCl, 4.5×10^{-6} , which differs from the value obtained electrochemically, and for that of HgBr, 8×10^{-7} . The accuracy of the above figure for HgCl is shown by the fact that the affinity of the reaction is 1.465 volts, when calculated from the e.m.f., and 1.454 or 1.42 volts—according to the values of the chemical constants employed—when calculated from the solubility.

T. H. P.

1360. *Connection between Electrolytic and Chemical Processes.* D. Reichstein. (Zeitschr. Elektrochem. 19. pp. 672-676, Sept. 1, and pp. 914-920, Dec. 1, 1918.)—The hitherto overlooked researches of J. J. Andrejew of 1907 on retardation in the solution of gold in aqueous cyanide show that, when the cyanide solution contains oxidising agents, the rate of solution increases to a maximum with increasing concentration of these agents and decreases afterwards. The author finds analogies in the electrolytic solution of active and passive (polarised) metals, in which an oxygen-metal alloy is first formed. When the oxygen concentration of this alloy is increased by increasing the proportion of the oxidising agent or the current, a critical oxygen concentration is reached. The formation of such an alloy (hypothetical solution) at the boundary between two phases is alone able to account for the chemical and the electrolytic phenomena with reversible electrodes. The experiments were made with the aid of the oscillograph.

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The second paper discusses the equilibrium conditions in those alloys. On the old hypothesis there was always to be equilibrium between electrode and alloy even while the current was flowing. But the passage of the current must disturb the equilibrium, and what remains constant is the sum of the concentrations of all the substances which constitute the hypothetical alloy. There is a compensation process, subject to chemical inertia, between the constituents, and on this process depends the polarisation. Reference is particularly made to the author's experiments of 1910 and 1918 on Pd electrodes in sulphuric acid which zinc salt is added; this addition results in a negative depolarisation, and zinc is deposited. H. B.

1961. *Electrolysis in Non-aqueous Solvents: Potassium o-Nitrobenzoate in o-Nitrobenzoic Acid.* J. C. Schall. (Zeitschr. Elektrochem. 19. pp. 880-888, Nov. 1, 1918.)—The author and R. Klien had, in 1898, when electrolysing sodium *o*-nitrobenzoate fused in its own acid, obtained nitrobenzol instead of di-*o*-dinitrophenyl expected on analogy with the behaviour of fatty acids dissolved in water. E. Berl had suggested that the electrolysis yielded, in the absence of water, sodium which caused the reduction to nitrobenzol. The author now electrolyses the potassium salt, fused at 160 to 170° in its acid, in a beaker, in which a small porous pot is placed (hot) containing the anode, a Pt-wire; its kathode, also of Pt, surrounds the pot. Electrolysis by currents of 0.5 amp. at 0.5 volt, the temperature mentioned being maintained, yielded mainly a blackish product, which could not be analysed; a smell of aniline, not of nitrobenzol, and of isonitrile was noticed. The attempted electrolysis of copper-*o*-nitrobenzoate according to M. Lilienfeld (D.R.P. 147,948) failed likewise. H. B.

1962. *Electro-deposition of Nickel.* C. W. Bennett, H. C. Kenny, and R. P. Dugliss. (Journ. Phys. Chem. 18. pp. 878-884, May, 1914.)—Calhane and Gammage [Abstract No. 2127 (1907)] in their investigations of the electro-deposition of nickel from a solution of nickel ammonium sulphate, using commercial Ni anodes, found that the current efficiency was greater with stationary than with rotating kathodes, whilst the amount of iron deposited as impurity increased when the kathode was rotated. The authors have confirmed these results, and, in the light of further experiments, give a satisfactory explanation of them, which is as follows: From the solution of nickel ammonium sulphate, which is neutral or slightly acid, hydrogen will first be deposited at the kathode. The solution in the neighbourhood of the kathode consequently becomes alkaline, and then, and only then, can Ni be deposited. Thus the efficiency of deposition of the Ni depends on the maintenance of a kathode film which is alkaline; stirring the electrolyte removes this alkaline film, more or less completely, depending on the efficiency of the stirring, and thus the current efficiency diminishes.

It was further shown that the efficiency can be started high and maintained high by adding a definite amount of ammonium hydroxide to the solution. The fact that the iron content of a deposit formed on a rotating kathode is greater than that formed on a stationary electrode is probably due to mechanical occlusion of the precipitated iron hydroxide from the alkaline solution. The iron content of the anode does not materially affect the efficiency. T. S. P.

SCIENCE ABSTRACTS.

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CORRIGENDA.

Abstract No. 884, line 1 : for Tachymeters, read Telemeters. Also p. 284, end line : for tachymetry, read telemetry.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1914.

GENERAL PHYSICS.

1363. *A Piezometric Sounding Instrument.* **A. Berget.** (Comptes Rendus, 158. pp. 1465-1467, May 18, 1914.)—Deep soundings are attended by numerous sources of error, principal among which is the shape taken by the line under water. The latter error is calculated by Krümmel, even in the most favourable case, to be at least one-thirtieth of the indicated depth. The present author has constructed a piezometer to avoid such error entirely, the principle being to measure the pressure at the depth attained by a manometric device. Water is adopted for the compressible fluid, since its compressibility is practically constant and its sensitiveness uniform at all depths. The instrument consists of a reservoir filled with water, whose base terminates in a long tube of $\frac{1}{4}$ mm. internal diam. which communicates with a side vessel full of mercury and open for reception of the pressure. The tube is silvered internally and graduated externally. The whole apparatus is 25 cm. long. As the apparatus descends, the mercury is forced up the small tube and dissolves away the silver, thereby denoting the amount of compression, and hence the depth attained. The apparatus was first graduated experimentally by means of a hydraulic press. A thermometer is attached to the side of the piezometer to allow a correction for thermal dilatation. The sensitiveness of the apparatus may be increased to any extent by enlarging the volume of the water reservoir, and diminishing the cross-section of the graduated tube.
H. H. Ho.

1364. *An Instrument for recording the Rate of Fall of Heavy Rains.* **E. Esclançon.** (Comptes Rendus, 158. pp. 1467-1470, May 18, 1914.)—The instrument consists essentially of a vertical tube with a comparatively small hole at the lower end which is otherwise closed. Rain is collected in a funnel of large diam. and allowed to flow into the open end of the tube. The velocity of discharge from the tube depends upon the pressure at the lower end of the tube, which in turn depends on the height of the column of water in the tube. Thus the latter is a measure of the rate of fall, for an

increase in the rate demands a higher velocity of discharge which is automatically provided for by an increase in the head of water in the tube. R. C.

1365. *New Measuring Machine.* F. Göpel. (Zeitschr. Instrumentenk. 84. pp. 180-188, June, 1914. Communicated from the Physikal.-Techn. Reichsanstalt.)—This is to measure the diameter of a cylinder carrying a coil of wire. The measuring parts are light and, being provided with slide movements, can be easily moved to various parts of the cylinder. The latter is so mounted that it can be rotated on its axis when between the contacts of the measuring machine. Microscopes are used to measure the position of the contact rods which have pointed ends. P. E. S.

1366. *Division Corrections of Toothed Wheels.* F. Göpel. (Werkstattstechnik, 7. pp. 648 and 675, 1918. Zeitschr. Instrumentenk. 84. pp. 84-91, March, 1914. Abstract.)—A simple apparatus is described for the determination of the corrections of toothed wheels employed in instruments of precision. The errors are plotted as diagrams showing the correction necessary at any point. C. P. B.

1367. *Comparison of the Standard Barometers of the Central Meteorological Institutes in Vienna, Belgrade, Sofia, Bucharest, Athens, and Rome.* W. Schmidt. (Meteorolog. Zeitschr. 81. pp. 202-208, April, 1914.)—This comparison was undertaken by the Vienna Institute in response to a resolution of the Conference of Directors of Meteorological Institutes and Observatories which met at Innsbruck in 1905. The author performed the comparisons between Oct., 1910, and July, 1911. The total number of single readings upon which the comparisons are based is 2270. The following table shows the mean differences between the standard barometers at the places mentioned and the new "Marek" standard barometer of the Vienna Institute :—

	First Standard.	Second Standard.
Buda-Pesth	-0.009 mm.	-0.255 mm.
Belgrade	+0.012	—
* Sofia	+0.188	-0.045
Bucharest	-0.027	-0.848
Athens	-0.198	-0.119
Rome	-0.085	-0.088

These results are considered to be fairly satisfactory.

R. C.

1368. *Densities of Metals at Different Temperatures.* P. Pascal. (Rev. de Métallurgie, 11. pp. 469-479, May, 1914.)—A series of measurements were made of the densities of tin, lead, zinc, antimony, aluminium, and copper at temperatures considerably above the melting-points of the metals. The apparatus employed by the author consisted of a small electric furnace containing a crucible in which the metal was fused, the temperature of the metal being measured by a thermo-couple. A bulb of fused silica ware was fixed at one end of the beam of a balance and was immersed in the molten metal by means of a lead weight; at the other end of the beam a scalepan was suspended for carrying a variable counterpoise. The temperatures between which the densities were determined were :—Sn from 282° C. to 988° C.; Pb, 827° to 969°; Zn, 418° to 918°; Sb, 681° to 1077°; Al, 658° to 925°; Cu, 1088° to 1295°. The results when plotted on curves show a regular diminution in density with rise of temperature. The author does

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not believe that these results should be used in calculating the contraction in volume which a metal undergoes in solidifying. The method is too indirect and would involve the comparison of very different samples of metal. [See Abstract No. 590 (1914).] F. J. B.

1369. *Tension Elasticity of Copper.* G. Colonnetti. (Accad. Lincei, Atti, 28. pp. 165-171, Feb. 1; 225-232, Feb. 15, and pp. 421-427, March 15, 1914. N. Cimento, 7. Ser. 6. pp. 11-18, Jan., and pp. 89-96, Feb., 1914.)—Investigates and tabulates the behaviour of copper under cycles of traction, and shows that the theory of elasticity covers only those cycles in which the traction is very small. E. E. F.

1370. *Plastic Deformation of Steel during Overstrain.* H. M. Howe and A. G. Levy. (Amer. Inst. Mining Engin., Bull. 88. pp. 585-600, April, 1914. Mech. Eng. 88. pp. 357-359, April 17, 1914. Abstract.)—The authors have made a microscopic study of the deformation of 0.2, 0.4, 0.75, and 1.45 per cent. carbon steels during the processes of cylindrical and conical punching, tensile testing, and wire-drawing. There are four aspects of flow in the plastic deformation of steel by overstrain: (1) the relative movements of the grains as a whole, (2) the relative movements of the cementite and pearlite within the grains, (3) the relative movements of the ferrite and cementite in the pearlite, and (4) the crystal unit slipping giving rise to the slip-bands of Ewing and Rosenhain. Intergranular movements are best shown by the uplifting of the grains on the upper surface of the plate polished previous to punching. The displacements are greater in cylindrical than in conical punching, but are confined to a narrower ring in the former case. Study of intra-pearlitic deformation shows that elongation or compression parallel to the stratification result in drawing out the cementite lines into squads and rearranging them *en echelon*. Sometimes the cementite lamellæ curve greatly, but cementite islands resulting from divorce annealing [see Abstract No. 886 (1918)] are shattered. F. C. A. H. L.

1371. *Fatigue Bending Tests made between 1892 and 1912 in the Materialprüfungsamt in Berlin-Lichterfelde on Mild Steel.* A. Martens. (Königl. Materialprüfungsamt, Mitt. 82. 1. pp. 51-85, 1914.)—Static and dynamic tests have been carried out on 41 examples of mild steel of different composition. The static tests included determinations of the yield-point (σ_s), elastic limit (σ_F), tensile strength (σ_B), and elongation (δ). Dynamic tests were carried out in a machine of the Wöhler type, by loading a 1.5-m. bar at both ends so that the stress (σ_A) on the outer fibres of the centre of the bar was 800 kg./cm.², and counting the number of revolutions required for fracture (ΣA). In one series, tensile tests were subsequently made on various portions of the fractured bar. During the bending tests a rough estimate was made of the rise in temperature at the centre of the bar. The results are collected in a 20-page table, and plotted in the form of curves showing $\log \Sigma A$ as functions of temperature-rise, σ_A/σ_F , σ_A/σ_s , and σ_A/σ_B . From the results the following conclusions can be drawn:—(1) When considerable heating takes place during fatigue tests, fracture will occur with less than 10^6 revolutions; but when the heating up is only slight, the number of revolutions required for fracture under identical conditions is considerably increased. (2) Fracture will only take place after a very large number of alternations (over 10^6) when $\sigma_A < \sigma_F$ or when $\sigma_A/\sigma_s < 0.85$ or $\sigma_A/\sigma_B < 0.45$. In alternating stress tests the permanent deformation exerts a far greater effect on the yield-point and elastic limit than on the tensile strength. Curves are also given showing the

effects of annealing and of chemical composition on log ΣA . The phenomena occurring during fatigue are so complicated that it becomes exceedingly difficult to offer a plausible theoretical explanation for the results. Effects of the alteration of shape and heating-up during the tests on the original mechanical properties; effects of variations in composition of, mechanical and thermal treatment of, and existence or non-existence of segregated areas in the material,—all tend to complicate matters and make a complete study of the subject very expensive both in time and money. F. C. A. H. L.

1372. *Effect of Notches in Continued Shock Tests.* E. Preuss. (Zeitschr. Vereines Deutsch. Ing. 58. pp. 701-708, May 2, 1914.)—In an earlier paper the author has shown that in a simple tensile test the effect of a notch is to increase the stress at the smallest diam. to between 1.48 and 2.48 times (depending on the shape of the notch) that which would exist in a plain bar of the sectional area at the bottom of the notch. During dynamic testing the effect is very much greater because there is so little time for stress-equalisation. Tests have been made in a Krupp impact bending machine (similar to that of Stanton) on mild steel bars provided with notches of different shape and size in comparison with plain cylindrical bars. In each case the minimum diam. was the same and equal to 18 mm. The results show that the deep notch always gives lower values than the shallow notch, and that the plain bars require 10.2 to 22.6 times as many blows for fracture as the notched bars. V-shaped notches give the lowest value. Attention is drawn to the dangers arising from stamping letters, figures, etc., in articles which are going to be subjected to shock. F. C. A. H. L.

1373. *Surface Film on Polished Metals.* G. T. Bellby. (Roy. Soc., Proc. Ser. A. 89. pp. 598-599, March 2, 1914. Nature, 92. p. 691, Feb. 19, 1914.)—Shows that the minute pits in a polished surface of copper are covered by a transparent or highly translucent film which crosses the empty pit without any support from below. By suitable methods of polishing the skin developed on the surface may be raised to a maximum thickness or reduced to a minimum. Photomicrographs in natural colours accompany the paper, and show the bluish film crossing the pits and the empty pits after the film has been dissolved by a 10 per cent. solution of ammonium persulphate acting for 20 to 80 seconds. The thickness of the film is probably of the order of 10 to 20 μ . E. E. F.

1374. *Experiments on Three Struts.* M. Rudeloff. (Verein z. Beförd. des Gewerbeleisses, Verh. 8. pp. 147-218, March, 1914.)—Describes elaborate experiments on struts. The shortening due to compression, and the lateral deflection are measured for the strut as a whole and for its component struts between the cross bindings. At each end plate of the strut is a ball seating, and the tilting of the end plate is observed. The results are given in copious tables. H. S. R.

1375. *Photo-elastic Effect in Strained Glass.* L. N. G. Filon. (Roy. Soc., Proc. Ser. A. 89. pp. 587-598, March 2, 1914.)—Investigates the manner in which the stress-optical coefficients of glass vary with the change of temperature. Glass slabs were enclosed in a double-walled copper chamber, and a circulation of steam was maintained between the walls. Light, after traversing the glass, was focused in a spectrographic camera. In the later experiments, prisms of small angle were cut from the material of the slabs, and the deflections of the various spectrum lines read off at the lower and
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higher temperatures. The author gives a table of the stress-optical coefficients for a Jena glass UV8199, and shows their variation in diagrams. They do not appear to be permanently fixed, but to vary with the time and the life-history of each individual piece of glass.

E. E. F.

1376. Critical External Pressure on Thin Tubes. R. v. Mises. (*Zeitschr. Vereines Deutsch. Ing.* 58. pp. 750-755, May 9, 1914.)—Derives an equation from the theory of elasticity and gives tables and curves to facilitate its application. Within the elastic limit, the equation given has a significance similar to that of Euler's equation for struts. Applications of the equation beyond the elastic limit are discussed by the author.

H. S. R.

1377. Elasticity of Rubber at Small Pressures. L. Bouchet. (*Comptes Rendus*, 158. pp. 1495-1498, May 25, 1914.)—Describes experiments on the compressibility of a water-filled cylinder of rubber totally immersed in water in a glass vessel. This vessel communicated by means of a stout connector with a glass tube the height of which was variable by means of a screw, and the amount of its motion capable of accurate measurement. By arranging that the area of the water surface in the vessel should be very large compared with that in the tube it was possible by raising the tube to produce exceedingly small but accurately determined changes in level (*i.e.* in pressure) in the gauge vessel. The rubber cylinder communicated at its upper extremity with a capillary tube, the level of the water in which was accurately determinable. The rubber was first subjected to a cycle of pressures traversed by definite small increments, the level of the water in the capillary being measured at each pressure 15 secs. after the application of that pressure. The deformations were found proportional to the applied pressures. A second cycle, traversed continuously and more rapidly, showed that in this case the deformations increased more quickly than the pressures and that the effects at increase and decrease were not the same. The value of Young's modulus calculated from the results obtained by this method was in fair agreement with the modulus found by tension.

J. W. T. W.

1378. Damping of Vibrations in Various Materials. I. Malmborg. (*Ann. d. Physik*, 44. 8. pp. 887-868, May 28, 1914.)—Describes experiments on some of the materials generally in use for lessening the tendency to vibration in systems subjected to impact. The substances employed included rubber, cork, and felt, the last-named being investigated both in the dry state and when soaked in various viscous fluids. A heavy cylinder was suspended by a bifilar system between two pads of the substance under investigation. These pads were pressed against the flat ends of the cylinder by massive blocks so arranged that different pressures could be produced on the pads. The cylinder was set in vibration by an axial blow of approximately known strength. The vibrations were registered photographically by means of a mirror, the time being similarly recorded from an electrically maintained tuning-fork. Experiments were made with three different strengths of impact, and with the material under varying degrees of pressure. It is found that the coefficient of damping for any material under constant pressure is practically independent of the intensity of the impact, and that this coefficient of damping, as well as the logarithmic decrement, are relatively small for the materials generally in use. An elastic material soaked in a viscous fluid, however, shows a very great improvement in both respects. Extensive tables and curves are given showing the behaviour of the different substances and these should be consulted if more detailed results are desired.

J. W. T. W.

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1379. Equations of Thermo-elasticity derived from Principle of Least Action. **A. S. de Doba.** (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 475-478, May 80, 1914.)—Mathematical. E. H. B.

1380. Photographic Determination of Difference of Longitude. **G. Lippmann.** (Comptes Rendus, 158. pp. 909-912, March 80, 1914.)—A device is described wherewith it is possible to obtain a photographic record of the difference of longitude between two stations without any transit instrument or personal observation error. A telescope is arranged to photograph a small region of the zenith at each station. Into each of these a collimator is adjusted so as to project the image of a small illuminated slit on the plate showing the star images, the beam of light from the collimator being adjusted to exact verticality by a mercury surface. By these means the artificial images are impressed simultaneously on the star plates at the two stations by employing electric sparks operated by a mechanical device to discharge exactly in unison with the receipt of a wireless signal from some central station such as the Eiffel Tower. The difference in right ascension of the two artificial marks on the photographs is then obtained from a knowledge of the star positions from standard catalogues. By taking a series of exposures on each plate the accuracy of the result can be appreciably increased.

C. P. B.

1381. Space Lattice of Diamond. **M. Born.** (Ann. d. Physik, 44. No. 4. pp. 605-642, June 4, 1914.)—A mathematical paper the scope and results of which may be thus summarised :—(1) According to the Braggs the diamond space lattice has the property that each carbon atom has four neighbours. Under the assumption that only these four neighbours exert molecular forces on the atom, diamond is shown to have only two molecular elasticity constants. (2) The vibrations proper to the lattice are rigorously calculated. It is shown that, as for the simplest regular lattice, the frequency is determined by a cubic. (3) The limiting case of long waves furnishes the relation between the three measurable and the two molecular elasticity constants. Among the measurable constants there is an equation of the second degree. (4) The formula for the specific heat is developed in a series in the reciprocal powers of the temperatures, according to the method of Thirring, and the first seventeen coefficients of the series are calculated. (5) The tabulation and plotting of the specific heat for various values of the elasticity constants is thus possible, and accordingly also comparison with the results of observations. (6) For an isolated carbon atom the appropriate frequency corresponds to a rest-ray wave-length of $11\ \mu$, in accordance with Einstein's statement. The frequency used by Debye may thus be calculated theoretically. E. H. B.

1382. Meteorological Observations of the German Antarctic Expedition, 1911-1912. **E. Barkow.** (Meteorolog. Zeitschr. 81. pp. 120-126, March, 1914.)—The expedition passed South Georgia in Dec., 1911, and reached the Antarctic continent on Jan. 30, 1912. In March the *Deutschland* attained her southernmost point ($77^{\circ}45'$ S.) in the Weddell Sea. On Dec. 17, 1912, the vessel regained the open sea. The more noteworthy of the facts brought out by the ordinary meteorological observations are the numerous periods when the barometer was extremely low, the low temperatures (mean -18.7° C. but the absolute minimum was only -86.9° C.), the small diurnal range of temperature ($>8^{\circ}$ C.), the comparative infrequency of gales and calms and the frequent occurrence of surface winds from all points of the compass, although the directions from SE. to W. are noted most often.

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Ascents of kites, registering balloons, and pilot balloons were made. A noteworthy feature is the frequency and magnitude of temperature inversions, the greatest of these being of $19\frac{1}{2}^{\circ}\text{C}$. in June. Above an inversion there usually occurs a layer of air which is nearly isothermal in a vertical direction. Observations with pilot balloons are specially interesting in view of theories of atmospheric circulation in the neighbourhood of the South Pole. Cases are found in which a strong westerly current occurs above a SE. surface wind of some 2000 m. in depth, thus agreeing with Meinardus' view of the circulation. On the other hand, on March 29, 1912, an east wind at the surface was succeeded by a NE. wind aloft, which persisted to the max. height attained, 9750 m.

R. C.

1383. Frost Periods in South Germany. R. Hennig. (*Meteorolog. Zeitschr.* 31. pp. 109-120, March, 1914.)—Apart from purely local influences the Alps considerably affect the climate of South Germany, for they modify the large oceanic depressions and they also completely prevent the Mediterranean influences, as exhibited by the climate of Northern Italy, from extending northward into Germany. The mountain ranges of Central Germany also affect the climate of South Germany by holding back the depressions which influence the weather of Northern Germany. A frost may prevail in the South when cyclonic conditions with temperatures above the freezing-point are experienced in the North.

The results of registering balloons at Lindenberg are utilised to predict the break-up of a frost period. Examples are shown of the variation of temperature with height on consecutive days at the end of a frost. The curves show a large temperature inversion above the cold surface layers with the usual fall of temperature above the inversion. The rate of fall of temperature gradually becomes more rapid on successive days until instability sets in concurrently with the break-up of the frost.

R. C.

1384. Calibration and Reading the Traces of Balloon Meteorographs. W. H. Dines. (*Meteorolog. Office, Geophysical Mem. No. 6*, pp. 147-152, 1914.)—The meteorograph consists of an aneroid box and a bimetallic thermometer. The record is obtained on a piece of silvered brass about the size of a postage stamp, and consists of a curve which represents simultaneous variations in pressure and temperature on a system of polar co-ordinates, in which the radius vector corresponds with temperature, the scale being nearly linear, while the angular co-ordinate gives roughly the pressure. The paper describes the method adopted by W. H. Dines to calibrate each record. The exact positions of definite pressures at definite temperatures are marked on the record itself before the ascent. When the actual record of the ascent has been obtained on the plate, corresponding recorded values of pressure and temperature are measured by placing the plate on the specially-constructed stage of a microscope which gives the polar co-ordinates above referred to by a scale in the eyepiece of the microscope and a scale and screw on the stage respectively. These are plotted on squared paper with reference to rectangular co-ordinates and the calibration marks are also measured and plotted. From the resulting diagram corresponding values of pressure and temperature for the ascent are obtained exactly by interpolation between the calibration lines. Values of temperature and height are derived from these by means of Laplace's formula; a graphical method, using semi-logarithmic paper and a special set-square, being employed. There is reason to suppose

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that the probable errors of the recorded temperatures are less than $1^{\circ}\text{C}.$, and that the error of the height at the base of the isothermal region (say at 8 to 11 km.) is less than 200 m. [See Abstract No. 1685 (1912).] R. C.

1385. *Depth of the Reversing Layer.* S. A. Mitchell. (Astrophys. Journ. 89. pp. 166-179, March, 1914.)—In the course of the analysis of the chromospheric spectra obtained at the total solar eclipse in 1905 [Abstract No. 616 (1914)], comparisons were made with the intensities of the lines with the lines of the Fraunhofer spectra, and also with laboratory arc and spark spectra. In addition, the lengths of the bright arcs were also determined, thereby giving material for computing the depth of the chromosphere corresponding to each spectrum line. The tabulation of the results is given for groups of elements, the grouping being in accordance with the periodic table. Some very noticeable differences are at once apparent; for instance the Fe-group lines extend to the least heights, and the lines of the rare-earth elements to the greatest heights. Also the enhanced lines, which are in all cases much stronger in the chromosphere than those not enhanced, extend to greater heights, the heights actually depending on the degree of enhancement. C. P. B.

1386. *Electric Field of the Sun.* H. Deslandres. (Comptes Rendus, 158. pp. 1187-1142, April 27, 1914.)—A discussion is given of the possibility of certain phenomena exhibited by the solar atmosphere being in whole or part due to the Stark-effect. Attention is drawn to the differences shown by laboratory experiments between the Stark electrical effect and the Zeeman magnetic effect. C. P. B.

1387. *Spectrum of the Chromosphere.* P. Salet and Millochau. (Comptes Rendus, 158. p. 1000, April 6, 1914.)—Several photographs of the spectrum of the solar chromosphere have been made with the large spectrograph attached to the equatorial of the Paris Observatory, the solar limb being doubled by Coudé interposing an Iceland-spar rhomb. The chromospheric lines showed almost the same appearance in the two spectra, thus suggesting that the Stark-effect due to a possible magnetic field is very feeble if at all existent. It is hoped to test the method further by means of greater dispersion apparatus. C. P. B.

1388. *Pressure in Solar Reversing Layer.* J. Evershed. (Kodaikanal Observatory, Bull. No. 86. Nature, 98. p. 224, April 30, 1914. Abstract.)—A new explanation is suggested to account for the general displacement of solar spectrum lines towards the red, which has of late years been ascribed to pressure effects. The author now shows that, after considering possible differences of level, the absolute and relative shifts can be satisfactorily accounted for by motions in the line of sight. He finds that in the higher regions of the solar atmosphere there is a movement of descent which is retarded in the lower levels. C. P. B.

1389. *Planetary Motions.* G. Nordström. (Ann. d. Physik, 43. 7. pp. 1101-1110, April 2, 1914.)—An examination is made of the formulæ for planetary orbital motions, employing the problem of relativity in the analysis. C. P. B.

1390. *Cosmic Dust in Solar System.* B. Fessenkoff. (Comptes Rendus, 158. pp. 1001-1008, April 6, 1914.)—An attempt is made to determine the probable relative density of the cosmical dust which is thought to exist in VOL. XVII.—A.—1914.

planetary space, the results being given in terms of the distance from the sun. The variation in density found is from 1.0 at unit distance, to 5.2 at distance 0.10. C. P. B.

1391. *Stellar Spectra and Cosmical Evolution.* H. N. Russell. (*Nature*, 98. pp. 227-230, April 30; 252-258, May 7, and pp. 281-286, May 14, 1914. Paper read before joint meeting of Astronom. and Astrophys. Soc. of America, and Amer. Assoc. for Advancement of Science, Dec., 1913.)—An attempt is made to correlate the recent results with regard to stellar parallax, proper motion, mass, brightness, and spectral type, in the endeavour to find some systematic indication of the method of evolution of cosmical bodies. It is shown that the differences in brightness between the stars of different spectral classes do not arise directly from differences of mass, and that probably the mean masses of the various groups of stars are extraordinarily similar. Also that the surface brightness of the stars diminishes rapidly with increasing redness. Evidence is given for accepting the view of stellar evolution consisting of two stages: an increase of brilliancy with advance of spectral type from red stars to white stars, with gradual increase of density due mainly to contraction, then a subsequent decrease of brilliancy with further advance of spectral type to another kind of red stars, accompanied by a further increase of density. This leads to various interesting proposals respecting giant and dwarf stars, as first suggested by Hertzsprung. [See also Abstract No. 200 (1914).] C. P. B.

1392. *Distribution of Stars and Spectral Type.* A. S. Eddington. (*Cambridge Phil. Soc., Proc.* 17. No. 4. p. 851, Jan. 30, 1914.)—The concentration of stars to the galactic plane is not shown equally by the different spectral classes, type B being chiefly represented. At one time this was regarded as possibly due to difference of distance according to the form of the stellar system, but this view does not accord with the determinations by Boss and Campbell of the average distances of stars of different spectral type. It appears now that the M type stars are on the average more remote and more luminous than those of type A. This raises the point whether the view of evolution shall be that the earliest type, having small velocities, are confined mainly to the galactic plane, or that they are more uniformly dispersed and possess initial high velocities as proposed by Russell. The author inclines to the former view. C. P. B.

1393. *Probable Order of Stellar Evolution.* H. N. Russell. (*Observatory*, No. 478. pp. 165-175, April, 1914.)—The question of the separation of stars of spectral type M into two groups in widely different stages of evolution has been criticised by Eddington [see preceding Abstract]. Discussing the data obtained from parallax observations of proper-motion stars it is suggested that the results leave no doubt that the number of stars of type M of brightness comparable with that of the sun must be very small compared with the number of those 100 times fainter. Further details are given of the author's views regarding the order of evolution of stars of various types of spectra. C. P. B.

1394. *Enhanced Lines of Manganese in Spectrum of a Andromedæ.* F. E. Baxandall. (*Roy. Astronom. Soc., M.N.* 74. pp. 250-256, Jan., 1914.)—Certain peculiar lines in the spectrum of α Andromedæ have been shown to be due to manganese under "enhanced" conditions, the agreement in wave-length being so close as to leave little doubt. Certain differences of relative intensity of the lines as found in laboratory spectra and in the

star spectrum are discussed, as these may be due either to differences of electrical condition in the star's atmosphere, or to the effect of closely neighbouring lines of other elements. C. P. B.

1395. Variations of Spectrum Intensity of δ Cephei and ζ Geminorum. I. Lehmann. (Acad. Sci. St. Pétersbourg, Bull. 6. pp. 428-428, April 1, 1914.)—Measurements were made on 88 plates of the spectrum of δ Cephei, and on 18 of the spectrum of ζ Geminorum, taking one plate as standard in each case. From the varying intensities of a selected series of lines a light-curve is deduced which shows remarkable similarity to the light-variation curve given by Stebbins by direct photometric determination. C. P. B.

1396. Hydrogen and Nebula Spectrum. J. W. Nicholson. (Roy. Astronom. Soc., M.N. 74. pp. 204-214, Jan., 1914.)—From the similarity of the wave-length formulæ for hydrogen and the nebula spectrum it appears likely that hydrogen marks a stage in the evolution of matter from a certain simple ring system. This idea is developed by an analysis of the various modifications of spectrum lines which may be produced by assuming different groupings of the electronic system. C. P. B.

1397. New Algol-type Variable in Pegasus. A. S. Williams. (Roy. Astronom. Soc., M.N. 74. pp. 215-225, Jan., 1914.)—Observations of the magnitude of a star in Pegasus show that it exhibits variability of the Algol type. Details are given from June, 1904, to Sept., 1907. The star is about the 10th magnitude. C. P. B.

1398. Short-period Variable XZ Cygni. C. Martin and H. C. Plummer. (Roy. Astronom. Soc., M.N. 74. pp. 225-238, Jan., 1914.)—Details of observations are given of the short-period variable discovered by Cereski in 1905. The mean photographic magnitude is 9.29. C. P. B.

1399. Peculiar Variable Star. E. C. Pickering. (Nature, 98. p. 198, April 23, 1914.)—Magnitudes for the period 1890-1912 are given for the peculiar star (081041, -41° 8911, HV8372). At first inspection the star appears to be a variable with period of about 20 years, varying from the eleventh to fourteenth magnitude. It is mentioned, however, that all other known long-period variables have a different spectrum to that of this star, and have periods not greater than 2 years. In this case the variations are probably irregular, and similar to those of the R Coronæ class. C. P. B.

1400. Proper Motions of Brighter Stars near Pole. H. S. Jones. (Roy. Astronom. Soc., M.N. 74. pp. 168-200, Jan., 1914.)—A detailed discussion is given of the relationship between the proper motions and spectral type of a number of the brighter stars within 17° of the Pole. The result of the investigation gives additional confirmation to the now well-established fact that the average stellar velocity increases progressively with advancing spectral type. C. P. B.

1401. Temperature of Orion Nebula. H. Bourget, C. Fabry and H. Buisson. (Comptes Rendus, 158. pp. 1017-1019, April 6, 1914.)—Interferential spectroscopic observations on the Orion nebula have been made from 1911 at the Marseilles Observatory, and from the results it is concluded that the strong double ultra-violet line at $\lambda 8726-8729$ is due to a gas having an atomic weight of about 8, while the chief nebula line at $\lambda 5006$ appears to be due to an element of atomic weight greater than hydrogen, but less than that giving the ultra-violet lines. Taking the limit of interference for hydrogen suggests that the temperature of the nebula is about $15,000^{\circ}$. C. P. B.

LIGHT.

1402. *Mirror Astrolabe.* H. Chrétien. (Comptes Rendus, 158. pp. 1144-1146, April 27, 1914.)—A modification of the Claude and Driencourt prism astrolabe is proposed, substituting for the prism a mercury bath and two plane reflectors fixed at 60° to each other, the angle of intersection being horizontal and normal to the plane containing the axial reflected ray. If the telescope objective is then arranged with its axis inclined 80° to the vertical, it will receive light from a star about 60° altitude along two paths: the first after reflection from the mercury surface and transmission, through the glass of one mirror; the second, after reflection from each mirror surface. Advantages are expected on account of the homocentricity of the two luminous periods, the augmented definition, and the possibility of constructing large instruments at moderate prices. C. P. B.

1403. *Coudé Spectrograph at Vienna.* A. Hnatek. (Zeitschr. Instrumentenk. 84. pp. 65-71, March, 1914.)—A powerful prism spectrograph has been adapted to the Coudé equatorial of the University Observatory at Vienna. The collimator is 1007 mm. focal length, and the camera is provided with two objectives of 800 and 580 mm. focal length respectively. An interesting description is given of the special method of suspension for securing rigidity and adaptability to adjustment with the optical axis of the main telescope, the whole spectrograph being suspended from strong girders near the roof of the observing chamber. The observation programme includes the determination of the radial velocities of 200 stars down to magnitude 6.0, contained in the zone between the pole and 60° North Declination. C. P. B.

1404. *Lateral Dark-ground Illumination.* G. Guglielmo. (Accad. Lincei, Atti, 28. pp. 482-488, March 15, 1914.)—Describes a spherical and a conical condenser specially suitable for physical (including Brownian motion) observations as distinct from biological studies. E. E. F.

1405. *Doppler's Principle for Light.* C. Fabry and H. Buisson. (Comptes Rendus, 158. pp. 1498-1499, May 25, 1914.)—Describes an ingenious method of readily demonstrating the above principle by means of a rotating disc of white paper illuminated by a Cooper Hewitt lamp placed at a distance of one diam. from the centre of the disc. By this means the edges of the disc always receive light travelling perpendicular to their direction of motion, and so act as sources of light identical with that of the lamp. These two sources are travelling at a high speed in opposite directions and the light from each in turn may be made to illuminate an interferometer. The size of the rings is observed to alter by an amount differing from the calculated value by only a few per cent., and the authors consider that by some experimental refinements, particularly the use of photographic records, the method might be employed to measure the velocity of light. J. W. T. W.

1406. *Dispersion and Absorption by Selenium.* K. Foersterling and V. Freedericksz. (Ann. d. Physik, 48. 8. pp. 1227-1284, April 16, 1914.)—Highly polished mirrors of metallic and of amorphous selenium were obtained by casting on plates of carefully cleaned plate glass. The values for VOL. XVII.—A.—1914.

$n^2(1 - \kappa^2)$ and $2n^2\kappa$ were found and compared with those demanded by Drude's electronic formulæ. It was found that free electrons have no influence, and that n_0^2 is sensibly independent of λ in both modifications, but slightly greater in the amorphous modification. The curves obtained indicate the existence of two proper oscillations, of 817 and 500 $\mu\mu$ respectively, common to both modifications, but with a larger number of oscillating electrons in the case of the metallic Se. The essential difference is, however, the presence of a third proper oscillation in the metallic Se, of wave-length 592 $\mu\mu$. E. E. F.

1407. *Selenium Photometry*. E. Carlo. (Rev. Électrique, 21. p. 357, April 8, 1914. Communication to the Congrès de l'Assoc. Franç. pour l'Avancement des Sciences, Tunis, 1918.)—Proposes to measure candle-powers by means of the deflection of a galvanometer in series with a selenium preparation illuminated by the light to be measured. If monochromatic light is used, and the precaution is taken of illuminating the selenium for half an hour by means of a 50-c.p. lamp before each measurement, consistent deflections are obtained for each intensity of illumination. E. E. F.

1408. *Ponderomotive Couple at a Source of Light and Electron Impulse Theorem*. P. S. Epstein. (Ann. d. Physik, 44. No. 4. pp. 598-604, June 4, 1914.)—Mathematical discussion of the views recently put forward by K. Schaposchnikow as to this couple and its connection with the Poincaré-Abraham impulse theorems from which the following conclusions are drawn :—(1) The difficulties found by Schaposchnikow spring from the fact that he uses a statement of the impulse theorem unsuited to the case under consideration. (2) The calculation gives a complete accordance between the resulting couple and the electromagnetic turning impulse in the sense of Abraham's theorem. (3) The seat of the electromagnetic turning impulse is the diffraction waves emerging from the crystal, as already supposed by Ehrenfest. [See Abstracts Nos. 1672 (1909) and 849 (1914).] E. H. B.

1409. *Spectrophotometric Study of Absorption, Fluorescence, and Surface Colour of Magnesium Platinocyanide*. F. G. Wick. (Phys. Rev. 8. Ser. 2. pp. 882-895, May, 1914.)—This paper does not lend itself to abstraction. The dichroic transmission, dichroic fluorescence, and surface colours of magnesium platinocyanide are investigated using a Lummer-Brodhun spectrophotometer. The relation of fluorescence and surface colour to transmission, the transmission of polarised light through sections cut perpendicular and parallel to the optic axis are studied. T. H.

1410. *Measurement of Reflecting Power and Determination of Optical Constants*. J. Koenigsberger. (Ann. d. Physik, 48. 8. pp. 1205-1222, April 16, 1914.)—A continuation of previous work [see Abstract No. 1877 (1904)]. The reflecting power of various substances was determined, including quartz, calcspar, galena, specular iron ore, antimonite, platinum, black matt paper, black velvet, soot, and a Brashear mirror. Various wave-lengths were employed, ranging from $\lambda 7000$ to $\lambda 4180$. Application is made to the determination of the refractive index from measurements of the reflecting power in two media. A. W.

1411. *Exaltation of the Magnetic Double Refraction of Fresh Bravais' Iron by Means of Acid*. A. Marchetti. (N. Cimento, 6. Ser. 6. pp. 418-426, Dec., 1918.)—The author has extended Tieri's work on the action of acid on recently prepared Bravais' iron solution [Abstract No. 1421 (1910)], use being
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made of the experimental arrangement previously described [Abstract No. 1066 (1918)], the liquid being, however, illuminated with white instead of monochromatic light. The sample of Bravais' iron solution employed was prepared later than 1908 and exhibited an initial double refraction of about $8/100$ of a wave-length in a field of about 14,650 units with a thickness of 8 mm. The variation of the double refraction with the time was examined in solutions of the iron containing different proportions of hydrochloric acid. The curves all follow similar courses, first rising rapidly to a maximum, and then falling gradually and becoming almost parallel to the time axis. The action of the acid thus produces an ageing of the iron similar to that which takes place spontaneously after the lapse of some years. It is evident that the formation of positive granules predominates in the early stages of this process, then proceeds less rapidly than, and subsequently at the same rate as, that of the negative granules. Finally, the negative granules begin to prevail over the positive ones and thus cause gradual diminution of the double refraction, which in time assumes a negative sign. T. H. P.

1412. Determination of Emissive Power in the Infra-red. M. Drecq. (Comptes Rendus, 158. pp. 1019-1022, April 6, 1914.)—For the purpose of determining emissive powers in the infra-red the author used a fluorine prism with curved faces as previously described by Féry [Abstract No. 586 (1910)]. Again, following Féry [see Abstract No. 861 (1909)], he used as receiver an angular surface, in conjunction with a thermopile. A piece of silver-foil 0.025 mm. thick was bent into a V-shape of angle 60° , and to the four corners were soldered wires of Bi 4 mm. long and 0.1 mm. diam. To the middle of the edge was soldered a silver wire 0.02 mm. diam. and 9 mm. long. The foil was covered with acetylene black, which possesses the lowest reflective power for the different wave-lengths. The receiving surface was 1 mm. wide and 8 mm. long. The arrangement as above described constitutes the hot junction, the cold junction being at the walls of a copper tube supporting the system. Connected to a galvanometer of 1.4 ohms resistance the element has a sensibility greater than that of thermo-elements recently constructed [see Abstract No. 927 (1911)]. Use has been made of the arrangement to obtain the energy spectrum of a black body at 1898° , and of a Nernst lamp taking 58.58 watts. For a black body the author used a piece of Pt-foil 0.05 mm. thick, rolled into a cylindrical shape 9 mm. diam. and 50 mm. long, a gap being left 1 mm. wide. This is heated by an alternating current, and with 100 amps. at 8 volts a temperature of 1600° is reached very quickly. A. W.

1413. Light Propagation in a Dispersive Medium. A. Sommerfeld. (Ann. d. Physik, 44. 2. pp. 177-202, May 12, 1914.)—Deals mathematically with the problem, distinguishing between phase velocity and signal velocity (or group velocity). [See Abstract No. 284 (1908).] E. H. B.

1414. Scattering of Light. L. Brillouin. (Comptes Rendus, 158. pp. 1881-1884, May 11, 1914.)—Mathematical paper dealing with the scattering of light by a transparent homogeneous substance on the theories of Planck, Einstein, and Debye. E. H. B.

1415. Variation of Titanium Furnace Spectrum. A. S. King. (Astrophys. Journ. 89. pp. 189-195, March, 1914.)—Several papers have previously been published by the author showing the remarkable differences which may be produced in the relative intensities of the spectrum lines of titanium as given

by different sources of electrical energy [see Abstracts Nos. 60 (1909); 1655, 1817 (1918)]. In the present paper an analysis is made of photographs taken of the spectrum of Ti volatilised in the electric furnace at three stages of temperature from 2000° to above 2600° C. The results show the approximate temperature at which a line appears, and its rate of growth in intensity as the temperature increases. An important conclusion is that, aside from the enhanced lines, almost the entire series of Ti arc lines are also given in the high-temperature furnace spectrum. Several excellent photographs of selected regions of the spectrum are given to show the variations of special prominence.

C. P. B.

1416. *Series Spectra and the Quantum Hypothesis.* J. Stark. (Deutsch. Phys. Gesell., Verh. 16. 6. pp. 804-806, March 30, 1914.)—From consideration of the Zeeman-effect, in connection with the recently observed electrical effect on spectrum lines, it results that the max. speed of electrons when emitting spectral series is below 200,000 cm./sec. The energy emitted by a radiating electron would then be below 1.8×10^{-17} erg, or some 100,000 times smaller than Planck's energy-quantum. Einstein's "light-cell" hypothesis also suffers in this connection. Considerations of the dimensions of the intra-molecular field of force in connection with the observed broadening of the series lines lead to the conclusion that the number of waves excited by a single impact is at least 1000. The "light-cell" must therefore have a length which greatly exceeds the wave-length, a conclusion which H. A. Lorentz (1910) deduced from considerations of interference. This deprives the light-cell hypothesis of its constructional and heuristic value, and the author, who formerly favoured it, is inclined to look for some other explanation of the observations which seemed to support it.

E. E. F.

1417. *Lead Pencil Comparison Spectrum.* J. Lunt. (Cape of Good Hope Observatory, Ann. 10. Nature, 98. p. 251, May 7, 1914. Abstract.)—For the study of many terrestrial and celestial spectra it is often necessary to arrange for a comparison spectrum capable of furnishing certain standard lines for the reduction. A convenient source for this has been found in the graphite of an ordinary lead pencil, which generally contains sufficient impurities to give lines of iron, titanium, vanadium, chromium, barium, strontium, calcium, and often gallium, scandium, yttrium, silicon, magnesium, manganese, in addition to the carbon.

C. P. B.

1418. *Variations of Arc Spectrum.* M. Hamy and Millochau. (Comptes Rendus, 158. pp. 1085-1086, April 20, 1914.)—In obtaining the arc spectrum of various elements when using the alternate-current arc, it was found necessary to vary the exposure time considerably owing to the changes of voltage of the supply current. An approximate formula is given to indicate the variations found.

C. P. B.

1419. *Effect of Electric Fields on Spectrum Lines.* O. M. Corbino. (Accad. Lincei, Atti, 28. pp. 238-240, Feb. 15, 1914. N. Cimento, 6. Ser. 6. pp. 449-451, Dec., 1914.)—In connection with the electric decomposition of spectrum lines discovered by Stark [Abstract No. 238 (1914)], the author looked for an anomalous double refraction near the lines by sending light through an auxiliary arc. But no such effect was observed.

E. E. F.

1420. *Spark Spectra of Elements in Extreme Ultra-violet.* L. and E. Bloch. (Comptes Rendus, 158. pp. 1416-1418, May 18, 1914.)—A continuation of
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previous work [see Abstract No. 1067 (1914)]. Measurements are extended to As, Sb, Sn, Bi, Al, and Cd. The lines have been mapped in general between 2100 and 1850 Å.

C. S. G.

1421. *Interference of Röntgen Rays.* R. Glocker. (Phys. Zeitschr. 15. pp. 401-405, April 15, 1914.)—The author gives a further account of some experiments made on the transmission of X-rays through crystals [Abstract No. 878 (1914)]. The crystals investigated in the present instance were those of KBr, NaCl, and KCl. A direct experimental estimation of the ratio of the lattice constants for crystals of KBr and NaCl (*i.e.* the ratio of the lengths of the sides of the elementary cubes of the crystals) gave a value 1.15 for the ratio, and this was found to be in close agreement with the value obtained on the assumption that a crystal of KBr behaves as a face-centred cube. The author discusses the possibility of a "molecule" space lattice in the case of NaCl and KBr, but comes to the conclusion, from analogy with KCl, which demands an "atom" space lattice, that the lattice points of crystals of KBr and NaCl are also beset with atoms and not molecules. All the results are in complete accord with the view taken by W. H. and W. L. Bragg of the structure of the space lattices in question.

E. A. O.

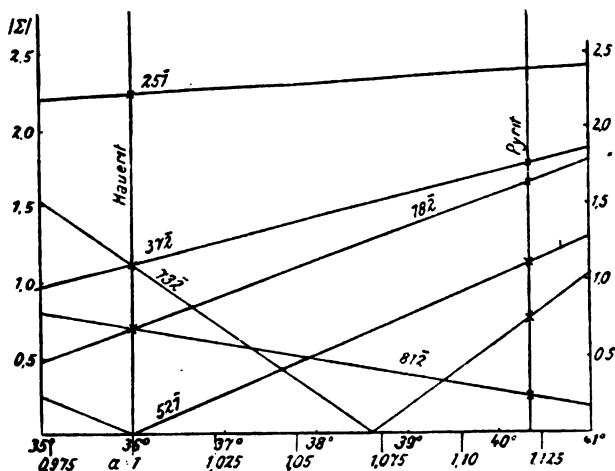
1422. *Crystal Structure from Interference Photographs by X-rays.* P. P. Ewald. (Phys. Zeitschr. 15. pp. 899-401, April 15, 1914.)—A method is described by which a more accurate determination of crystal structure can be made from the study of Laue-graphs. It is pointed out that since the interference pattern by Laue's method shows reflection at all faces, it is suitable to make visible the fine points of the structure with greater accuracy than is possible by Bragg's reflection experiments. Bragg's method is objected to on two grounds: (a) it is difficult to maintain the X-ray bulb constant during the whole time of the reflection exposure, and consequently the relative intensities of the various orders can only be determined approximately; (b) it is difficult to interpret the intensities obtained. In order to estimate how much of the weakening is determined by the structure, and to draw conclusions as to the arrangement of the reflecting particles, we must know the "ideal" falling-off of the intensity of the spectra of higher orders, *i.e.* not only the falling-off conditioned by the increased resolving power at the higher orders, but also the decrease of intensity produced by the increased coarseness of the surfaces on account of heat motion. This "ideal" falling-off of the intensity is different from crystal to crystal, and cannot be calculated beforehand without a knowledge of the structure and thermal properties of the crystal. It is pointed out that in Bragg's experiments no difference is made between rock-salt and pyrites in this respect, and thereby an error is introduced into the calculation of the structure. In the present method it is assumed that the type of the crystal grating is already known. The intensities of the spots of the interference patterns depend partly upon the wavelength and partly upon the more or less good superposition of effects due to the various elementary space gratings out of which the structure is built up. The amplitude of an interference ray is given by the structure factor Σ , which arises from the fact that the interference maxima of the single space gratings have a particular phase-difference. The variation of intensity between neighbouring wave-lengths caused by the structure factor of a complicated grating can be very large. In fact, in the case of a hemihedral interference pattern (*e.g.* pyrites), the hemihedral spots have various intensities simply on account of the factor Σ , although their wave-lengths, absorption, etc., are identical.

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If now there is only one parameter of the structure unknown, then for a few chosen spots of the same or neighbouring wave-lengths the variation of Σ with the parameter can be determined, and we can then determine with ease that value of the parameter which best explains the intensities. In the case of pyrites, Bragg finds that the distance between the sulphur atoms is $\frac{1}{2}$ that between the iron atoms. A consideration of the intensities of the various spots, however, shows that this ratio is incorrect. If we consider a more general system whose distance ratio is $a/5$, then the structure factor for spots with mixed indices is given by :

$$\Sigma = (-1)^{h_3} \cos \frac{\pi}{5} \cdot a (h_1 - h_2 - h_3) + (-1)^{h_1} \cos \frac{\pi}{5} \cdot a (-h_1 + h_2 - h_3) + (-1)^{h_2} \cos \frac{\pi}{5} \cdot a (h_1 - h_2 + h_3) + (-1)^{h_1 + h_2 + h_3} \cos \frac{\pi}{5} \cdot a (h_1 + h_2 + h_3).$$

Taking two spots with like wave-lengths, such as $25\bar{1}$ and $52\bar{1}$, if the indices are put into the above formula for Σ , we can get the values of Σ for various values of a . In the Fig. the absolute value of Σ is plotted as a func-



tion of a . This Fig. shows clearly how the intensity of $52\bar{1}$, which is about $\frac{1}{4}$ that of $25\bar{1}$, is nil when $a = 1$, but for larger values of a it approaches the correct value, viz. $\Sigma_{521} = \frac{1}{4}\Sigma_{251}$. When a is given values between 1.10 and 1.125, we obtain values of Σ which best explain the intensities, hence it is concluded that the true value of a lies between 1.11 and 1.125, and that likewise the distance ratio is not $\frac{1}{2}$ but about 1.12/5.

The crystal hauerite is also discussed.

E. A. O.

1423. Debye-effect. E. Schrödinger. (Phys. Zeitschr. 15. pp. 497-508, May 15, 1914.)—A theoretical discussion which establishes the following points:—(1) The interference pattern of a grating line does not depend on the edge conditions provided the number of points is sufficiently large. (2) Hence the intensity of the interference pattern is markedly affected only by such pairs of atoms as are not too far apart. (3) Theory indicates a diminution of the photographically observed intensity, and its final disappearance with rising temperature, as accords with experiments. [See Abstracts Nos. 1968 (1918) and 680 (1914).]

E. H. B.

1424. Secondary X-rays. J. Laub. (Phys. Zeitschr. 15. pp. 842-844, April 1, 1914.)—A continuation of previous work [see Abstracts Nos. 877 and 868 (1914)]. Röntgen rays were sent through a lead tube 5 cm. long, 8 cm. wide, and 0.7 cm. thick, and were allowed to fall on a piece of sheet zinc 6 cm. long, 2.9 cm. wide, and 0.6 mm. thick, placed at the end of the lead tube. Thus the rays leaving the end of the tube chiefly passed through the zinc, but part emerged through the segmental slits at the sides. Behind the zinc sheet were three photographic plates, the distances being as follows:—Antikathode to zinc 85 cm., zinc to plate (i) 2 cm., zinc to plate (ii) 8 cm., zinc to plate (iii) 14 cm. The plates when developed showed distinct images of the slits, and also, round these, secondary images similar to the first but not so intense. Photographs are reproduced and the results discussed. A. W.

1425. The Passage of α -Particles through Hydrogen. E. Marsden. (Phil. Mag. 27. pp. 824-880, May, 1914.)—On the nucleus theory of an atom Rutherford and C. G. Darwin have recently discussed the relative motions of an α -particle and the nucleus of an atom in an intimate collision [see Abstracts Nos. 1081 and 1082 (1914)]. In the case of an encounter of an α -particle of velocity V with the nucleus of a hydrogen atom, if the latter is projected in a direction making an angle θ with the original direction of the α -particle, then the velocity of the "H" particle is given by $u = 1.6 V \cos \theta$. From Bohr's formula for the "velocity curve" of a charged particle, it can be deduced that in an end-on collision, *i.e.* $\theta = 0$, the "H" particle will have about four times the range of the α -particle producing it. Consequently, in the passage of α -particles through hydrogen the "H" particles may be looked for well beyond the range of the ordinary α -particles, and in the experiments to be described evidence of their existence has been found. More detailed experiments are in progress to investigate whether the distribution of their velocities, and relative motions with regard to the α -particles producing them, is in agreement with the calculations from the simple assumptions. The apparatus used consists of a wide tube about 1 m. in length and 9 cm. in diam., closed at one end by a zinc-sulphide screen, and at the other by a glass plate on a ground flange. A source of about 25 millicuries of radium emanation contained in an α -ray tube was mounted inside a sheet-iron cylinder so that it could be moved along the tube by a hand electromagnet. The tube was filled with hydrogen at atmospheric pressure, and scintillations were counted on the zinc-sulphide screen for different distances between source and screen. The results show that, in hydrogen, particles capable of producing scintillations are produced which can travel at least $8\frac{1}{2}$ times as far as the α -particles. An experiment is described which shows that these particles are actually generated in the hydrogen. An experiment is also made to throw some light on the direction of projection of the H-particles. The scintillations produced by the H-particles differ little from those produced by α -particles except that they are not so intense; the luminosity of the screen due to the β - and γ -rays from the source is considerable. Further, the counting is made more difficult owing to the small rate at which the H-particles can be made to strike the screen, due to the large distance of the source necessitated by the long range of the α -particles. Experiments are therefore made in hydrogen at high pressure so that the α -particles have a smaller range, and by placing the apparatus in a strong magnetic field the β -rays are prevented from striking the screen. The method is somewhat unsuitable for a determination of the number of H-particles produced by a given number of α -particles of known velocity, since α -particles of all velocities are present, and, further, the mini-

mum velocity at which a H-particle will produce a visible scintillation is a matter of conjecture. However, the number actually observed is about that to be expected from calculations on Darwin's formula, making reasonable assumptions for the difference between the theoretical and experimental conditions. A more convenient method of making a comparison between theory and experiment is furnished by the use of a thin film of some substance rich in hydrogen, such as paraffin wax or indiarubber. When α -particles fall on such films, H-particles may be expected to be ejected, and experiments have shown that this is actually the case. The observations are at present being continued so as to study the distribution and number of ejected H-particles when a parallel beam of α -particles of known velocity passes through these films.

A. E. G.

1426. *Distribution in Intensity in the Magnetic Spectrum of the β -Rays of Radium (B + C).* J. Chadwick. (Deutsch. Phys. Gesell., Verh. 16. 8. pp. 883-891, April 80, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The pencil of β -rays from a fine source of Ra(B + C) was deflected in known magnetic fields and the distribution in intensity in the magnetic spectrum investigated, both by direct counting [see Abstract No. 1878 (1918)] and by an ionisation method. The results showed a continuous spectrum, with a line spectrum of relatively very small intensity superposed. In the region of slow velocities a few stronger lines were found. These results appear to contradict those obtained by the photographic method [Abstract No. 251 (1914)] which seemed to lead to the conclusion that the β -rays of most radio-active substances are emitted in homogeneous groups. The difference between the results of the electric and photographic methods may be explained by the extremely great sensibility of the photographic plate for slight variations of intensity.

E. M.

1427. *Relative Ionisation in Various Gases by β -Rays of different Velocities and the Ionisation produced by γ -Rays.* R. D. Kleeman. (Cambridge Phil. Soc., Proc. 17. 4. pp. 814-820, Jan., 1914.)—A beam of heterogeneous β -rays was obtained by placing a quantity of Ra at one of the entrances of a bore-hole passing through a thick lead block. The beam was allowed to pass into an ionisation chamber where the relative ionisation in methyl iodide, hydrogen, and air were measured. By means of a magnetic field the rays could be hardened to any extent by bending some of the slower rays aside. It was found that this process produced no change in the relative ionisations, showing the latter to be independent of the velocity of β -rays.

The author next discusses the bearing of these results on the process of ionisation by γ -rays, since it is known that the relative ionisation of the above gases differs largely when γ -rays of different penetrating power are used. It is concluded that these latter differences are closely connected with the secondary γ -radiation excited in the walls of the ionisation chamber used.

E. M.

1428. *Distinction between the Penetrating γ -Radiation of Mesothorium and Radium.* O. Hahn. (Le Radium, 2. pp. 71-74, March, 1914.)—It is well known that mesothorium is chemically non-separable from radium, so that commercial mesothorium obtained from monazite sands generally contains of the order of 20 % of Ra. Estimations of the relative amounts of Ra and Meso-Th in a specimen are easy by the emanation method, but this involves breaking the containing tube. The author has made careful measurements of the absorption by lead of the γ -rays of various preparations with a view to

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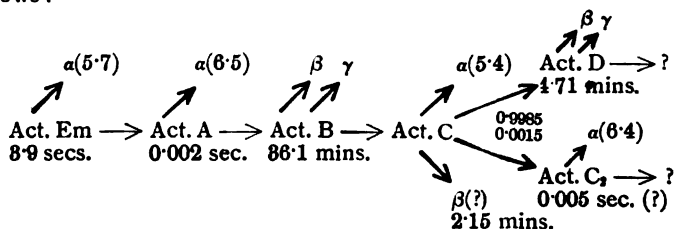
distinguishing them by this method. The preparations used were:—(1) RaBr₃, pure. (2) Commercial mesothorium freshly prepared. (3) Commercial mesothorium, 2 years old [*i.e.* having grown radio-thorium]. (4) Freshly prepared mesothorium, free from Ra. (5) Radio-thorium. The electroscope used was of lead with walls 8.8 mm. thick, and the following relative ionisations were obtained:—

Mm. Lead.	(1) Radium.	(2) Mesothorium (New).	(3) Mesothorium (Old).	(4) Mesothorium (without Ra).	Radio- thorium.
8.8	100	100	100	100	100
5	84.5	86.7	85.5	87.8	86.5
10	57.6	60.7	60.1	60.8	63.1
15	41.9	44	44.6	48.2	47.1
20	31.5	32.1	33.2	31.5	36.8
25	24.2	23.7	25.2	22.8	29.1
30	18.6	17.7	19.4	16.7	23.8
35	14.8	13.4	15.5	12.2	18.8
40	11.8	9.9	11.8	9.2	13.8
45	9.0	7.5	9.1	6.8	12.4

E. M.

1429. *Transformations in the Active Deposit of Actinium.* E. Marsden and P. B. Perkins. (Phil. Mag. 27, pp. 690-708, April, 1914).—It is well known that the "C" products of the active deposits of Ra and Th are anomalous in that in both cases the atom has two distinct modes of transformation, *i.e.* it breaks up with emission of either an α - or a β -particle. In the case of ThC, owing to the fact that the chance of disintegration in either of the two ways is of the same order, it has been found possible to examine the process in considerable detail, and a scheme of transformation has been arrived at [see Abstract No. 97 (1914)]. From the close analogy of the thorium and actinium series it is to be anticipated that ActC should also show two modes of disintegration, and the present experiments are made to test this point. In the cases of both ThC and RaC the branch disintegration involves the emission of a long-range α -particle, 8.6 cm. in the former case and 6.94 cm. in the latter. Further, with the whole series of products in equilibrium, the total number of α -particles of the two ranges emitted by the "C" products is equal to the number from the emanation and "A" products on the main series. From the experiments of Geiger such a result must also hold for ActC if a branch occurs in this product. Experiments are consequently made to test whether any long-range α -particles are emitted from ActC, the general evidence indicating that the number of such particles must be small compared with the number of range 5.4 cm. which constitute the main radiation. The simplest method of making such an experiment would be to take a source of actinium active deposit, and to count the scintillations on a zinc sulphide screen placed in air at different distances from it. Such an experiment had already been tried by Geiger, and it is now repeated without finding any α -particles beyond 5.4 cm. However, with the sources of actinium available, the number of α -particles falling on an area of 1 sq. mm. (the area of the field of the microscope) at distances greater than 5 cm. is very small. Consequently a sheet of mica, of air equivalent over 5 cm., was interposed between the source and screen so that a smaller distance between the two could be used. The experimental arrangement is shown. The α -par-

ticles from the source A passed through a sheet of mica B and impinged on a zinc-sulphide screen Z, where the scintillations were observed by a microscope M. The distance of A to Z could be varied in different experiments, and was generally between 0.9 and 1.5 cm. The thickness of mica was also varied in different experiments between 5 and 7 cm. air equivalent. Curves for ActC, RaC, and ThC₂ respectively are given. The curve for ActC differs from the others, and indicates that about 0.15 % of the particles can penetrate much further than the ordinary α -particles of range 5.4 cm. The range of the new α -particles or the range at which scintillations cease to be produced is about 8.4 cm. The absence of RaC in the source is proved, so that the above experiments indicate that the α -particles of ActC are complex, and that 0.15 % have a range of 8.4 cm., while the main number have a range of 5.4 cm. The ionisation curves of α -particles from Po, ActC, RaC, and ThC are also investigated. It can be at once observed from an inspection of the figure given that the different curves are not superposable: for instance, the distance between the maximum and the end of the range is least for Po and greatest for ThC₂. As the α -particles of ActC and RaC have ranges intermediate between those of ThC₂ and Po, it is to be expected that the curves should show intermediate characteristics. The results are in general agreement with this expectation. The experimental curves are, however, almost identical; whereas theoretically the actinium curve should be nearer to that for Po, since the range of the α -particles of ActC is smaller than the range of the α -particles of RaC. By analogy with the transformations in the active deposits of thorium and radium, the actinium active deposit may be written as follows:—



In a table the disintegration constants and properties of the products following the emanations are given. The α -rays are characterised by their ranges in air at 15° C. and 76 cm. Hg, and the β -rays and γ -rays by their respective absorption coefficients in Al, the numbers for γ -rays being taken from the tables of Rutherford and Richardson. In almost every column the Th product lies intermediate in its characteristics between the corresponding products of Ra and Act. No direct information is at present available as to whether this is also the order of the atomic weights. An exception occurs in the "B" products, the transformation constants and the absorption coefficients of the hardest γ -rays following the order Ra > Act > Th. Another exception is that the ranges of the particles of the C₂ products (= RaC') follow the order Th > Ra > Act.

A. E. G.

1430. *Decay of Radium Emanation in an Atmosphere of Helium.* W. Marckwald. (Phys. Zeitschr. 15. pp. 440-441, May 1, 1914.)—The experiments show that the activity of RaEm, as measured by γ -rays, decays at the same rate when helium is present as in presence of air.

E. M.

HEAT.

1431. *Cooling of Spheres.* F. Vercelli. (N. Cimento, 6. Ser. 6. pp. 427-486, Dec., 1918.)—Two spheres of different substance but equal radius, cooled from the same initial temperature until they possess a given final temperature at the centre, have coefficients of thermal conductivity which are directly proportional to the density and specific heat, and inversely proportional to the time required for the cooling. The author describes a method governed by rigorous formulæ, and involving the use of elliptic functions. E. E. F.

1432. *Diffusion-coefficient of Gases and Viscosity of Gas-mixtures.* J. P. Kuenen. (Konink. Akad. Wetensch., Amsterdam, Proc. 16. pp. 1162-1166, May 29, 1914.)—A previous communication [Abstract No. 1248 (1918)] on the diffusion-coefficient, D , of gases showed that the contradiction between the theories of O. E. Meyer and Maxwell-Stefan-Langevin could be largely removed by taking into account in the former theory the persistence of molecular movement. On this improved theory a much smaller change in D with the composition of the mixture is involved, in contrast to the second theory mentioned which makes the coefficient entirely independent of composition. The author has now calculated D for two pairs of gases, namely carbon dioxide—hydrogen and argon—helium, which seemed specially suitable owing to the great difference in the molecular masses. A further modification to the formulæ has now to be given expressing the mutual attraction influence of the molecules. A difficulty arises here, since in the viscosity of a mixture not only the attraction of unlike molecules but also that between like molecules plays a part. If the observations could be represented by a rigorous theoretical formula the various attractions could be separated, but as this is not the case an estimation has to be made. The agreement between observation and calculation, viz. for CO_2 and hydrogen, 0.58 and 0.551 is very satisfactory, but for argon and helium 0.70 and 0.597 is less close. The viscosity of gas-mixtures is considered, and the ordinary gas theory found to give, without being strained, a maximum in the viscosity in accordance with observation—a result hitherto not explained. H. H. Ho.

1433. *Natural Radiation from a Gas.* G. Green. (Roy. Soc., Proc. Ser. A. 89. pp. 581-587, March 2, 1914.)—A mathematical investigation with the object of deriving a form of pulse in agreement with Planck's law of radiation at any temperature, and of discovering if any information can be obtained regarding the constitution of natural radiation by decomposing this pulse. The author arrives at a form of pulse which represents complete radiation at all temperatures, and the statistical relation between it and the harmonic constituents of the radiation emitted by the various groups of molecules. A fuller discussion is reserved for a later paper. E. E. F.

1434. *Quantum Effect in Monatomic Gases and Liquids.* A. Eucken. (Preuss. Akad. Wiss. Berlin, Ber. 22. pp. 682-698, 1914.)—Describes experiments on the compression, etc., of helium and hydrogen and theoretical deductions therefrom. It is concluded that the work is incompatible with the acceptance of a zero-point energy. [See Abstracts 682 and 1018 (1918).] E. H. B.

1435. *Thermodynamic Equilibrium.* I. Bródy. (Ann. d. Physik, 44. No. 4. pp. 585-592, June 4, 1914.)—Mathematical discussion of thermodynamic equilibrium and its disturbance under general external conditions. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1436. *Measurement of e/m for Kathode Rays.* **L. T. Jones.** (Phys. Rev. 8. Ser. 2. pp. 817-824, May, 1914.)—This determination of e/m and v is by a modification of the usual method employing the simultaneous electrostatic and magnetic deflections. The modification is the result of an attempt to eliminate as nearly as possible the errors of measurement of the deflections and the correction due to the field distribution at the ends of the electrostatic plates. This is brought about chiefly by the position in which the photographic plate was placed, viz., on the lower electrostatic plate, the kathode rays passing at grazing incidence along the upper electrostatic plate; the two plates being mounted at 1 cm. apart. Thus the fields were uniform over the entire path of the deflected kathode beam and its deflection was constant for all fields.

The mean of twenty successive photographs gave $e/m = (1.75 \pm 0.08) \times 10^9$.
E. H. B.

1437. *Possible Union of the Electromagnetic and Gravitational Fields.* **G. Nordström.** (Phys. Zeitschr. 15. pp. 504-506, May 15, 1914.)—A mathematical paper in which it is shown that a single treatment of the electromagnetic and gravitational fields is possible if one regards the four-dimensional space-time world as a surface of a five-dimensional world. [See Abstracts Nos. 7 and 1191 (1914).]
E. H. B.

1438. *A Comparison of the Electrical Conditions of the Atmosphere at Kew and Eskdalemuir, with Notes on Observations of Atmospheric Electricity made in Other Countries.* **G. Dobson.** (Meteorolog. Office, Geophysical Mem. No. 7. pp. 155-160, 1914.)—Potential gradient is the only electrical element which is recorded continuously at either of the two observatories. For this purpose a "water-dropper" type of instrument is used. To obtain mean figures 10 quiet days per month have been selected and tabulated at Kew, but owing to the more disturbed record obtained this method could not be used at Eskdalemuir. Accordingly two methods were adopted here: first all "O, a" days were taken, that is, days which gave no negative gradient and throughout which the potential was steady, and second, all "complete ordinary" days were used, that is, all days were omitted on which the potential was so unsteady that the curve left the paper at any time during the day. Owing to the much greater number of days obtained by the second method it is preferred to the first for getting mean results, but in most cases results by both methods are given. The winter type of diurnal variation is very similar at Kew and Eskdalemuir, but in summer there is a marked difference, the potential at Eskdalemuir maintaining a steady and fairly high value during the night hours, while Kew shows a well-marked minimum at 4 a.m. The type of the annual variation is similar at both observatories, but the range is decidedly smaller at Eskdalemuir. The mean potential gradient is also smaller here and amounts to not much more than two-thirds of the value for Kew. In considering the results for conductivity and the number of ions in the air considerable differences appear at the two stations.

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In particular the ratio of the number of positive to negative ions (q) shows a large annual variation at Eskdalemuir, but is almost constant at Kew. The conductivity, on the other hand, has a well-marked variation at Kew not shown at Eskdalemuir. It is found that this annual variation of conductivity is almost entirely due to a variation in the number of ions and not to any change in their mobilities. Results from certain foreign stations are also given for comparison.

J. S. DI.

DISCHARGE AND OSCILLATIONS.

1439. *On the Conditions of the Variable Influence of Light upon the Spark, and on the Means of Regulating Sparks.* M. Bonch-Bruevich. (Russian Physico-Chemical Soc., Journ. 45. 8. pp. 481-458 [Physical Part], 1914.)—In reviewing the experiments of Lebedinski and Mitkiewicz with the direct rays of an arc upon the spark-gap, the variable nature of the effects produced led the author to the idea that in the spark itself, under the influence of the light, two completely opposing processes arise. The task of regulation of the spark, with a view to obtaining at will the one or the other effect, then followed. Lebedinski and Mitkiewicz had indicated a method of procuring a "sensitive" spark, that is, one which would simultaneously suffer extinction under a strong, and ignition under a feeble, light. Commencing with a small distance, the spark-gap between a sphere (—) and a pointed rod (+) was gradually enlarged, observation being at the same time kept upon the effect of the light upon a thin spark. This effect, in the beginning, was that of sharply kindling the spark, and if the power of the light was diminished an enfeeblement followed. For a certain sufficiency of spark-length extinction

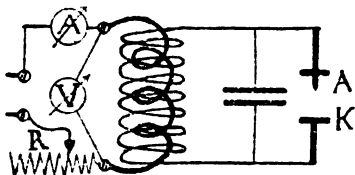


FIG. 1.

was reached, and at this point the weakening of the light either kindled the spark or else produced an indeterminate effect. In the last case, when the spark was shortened, a point was reached when both phenomena could be clearly observed. To further investigate these and other effects the author, working in the physical laboratory of the Nikolaevski Engineering Academy, constructed the arrangement shown in Fig. 1 for obtaining the spark. The Oerlikon transformer (15,000 volts, 1 kw., transformation ratio 800) there shown is supplied with alternating current from a small converter. For regulation, either strength of current, or the periodicity (80-50), can be altered. V is a Weston voltmeter with scale permitting of $\frac{1}{4}$ -volt readings. It measures the pressure at the terminals at the primary, indicating at the same time the character and the relative magnitude of the change in the spark pressure resulting from various factors, and permitting of judgment as to alteration of pressure that occurs at the ends of the gaseous space. By means of this arrangement it has been possible to trace the mutual action between light and electrical discharge afforded by the change in the spark space. The source of radiation was a voltaic arc, in some experiments of 9-14 amps., and in others 80 amps. The arc was customarily placed at a

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distance from the spark-gap of about 1 m. At the commencement of the investigations the author used for the positive electrodes steel needles of various thicknesses, but it became apparent to him that it was not the pointed form of a thin needle which actually affected the character of the phenomenon, as might be suggested on first thought, but that it was the change in the distribution of the lines of force of the field. Experiment showed that

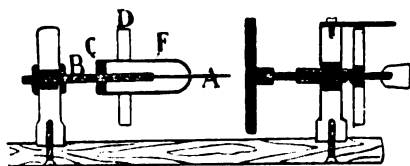


FIG. 2.

if a metallic disc of mushroom form were caused to slide along the needle with the curved face facing towards a spherical electrode, then according to the position of the disc it was possible to change the potential of discharge, also the form of the discharge, as well as the influence of radiation on the spark. So that what had been previously attempted by degrees of fineness of the electrode could now be secured by the application of a metallic disc of 1 cm. diam., keeping the electrode itself unchanged. Three positions of the disc correspond in effect to (1) a very blunt electrode (disc covering point); (2) a very sharp one (disc moved as far from point as possible).

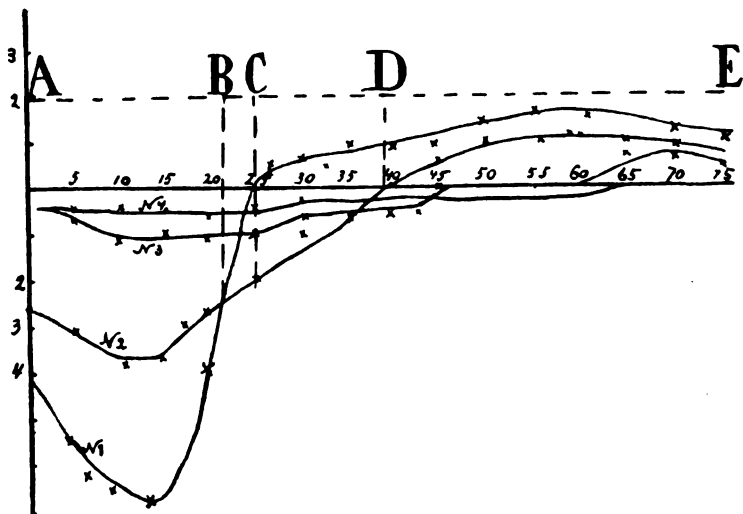


FIG. 3.

In the third position (disc in middle position) an effect was produced as if the needle A were gradually and continuously sharpened. With this appliance the author claims to be able to study what influence a change of length of the spark has upon this or that process while the electrode is virtually being varied in acuteness.

The latest form of the author's spark measure is exhibited in Fig. 2. On a brass screw-threaded spindle B, secured in an ebonite bushing, moves the

ferrule C, which is itself fastened to the brass body F. Through an opening in F passes a thin gold needle A metallicly connected to the spindle B. Gold is preferred owing to its merely gradual wear, and to its resistance to oxidation. The rubber disc D serves to turn the cylinder and to count revolutions: one revolution moves the cylinder 1 mm. The cathode is sometimes a brass disc and sometimes a sphere 1 cm. in diam. The investigations of the author are illustrated graphically. For instance, Fig. 8 shows the effects, respectively, of powerful and feeble radiations, while the position of the mushroom-shaped disc is varied, and consequently one effect passes over to the other. Fig. 4 exhibits the effects when the arrangement of Fig. 2 is employed and the position of regulator F is altered.

The pitches of the screw-threads of the regulators for Figs. 8 and 4 differ, but the scale of the drawing is the same for both.

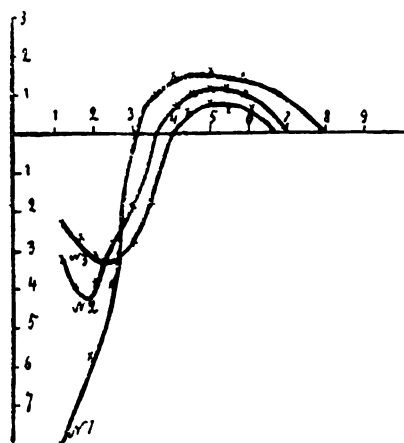


FIG. 4.

For the graph of Fig. 8 the cathode employed was a sphere 1 cm. in diam., and in the case of that of Fig. 4 it was a brass disc 8 cm. in diam. Diminishing the surface of the cathode, without altering the nature of the phenomenon, increased the distance between the points of inversion of the effect, giving a chart akin to that of Fig. 8. Increase in this distance is also obtained by shortening the spark, in which case the curves plotted are those of Fig. 4.

Comparison of the effects of two radiations of different intensity, for example in Fig. 8, that of a more powerful light, No. 1, and of a more feeble one, No. 2, shows that, in proportion to an increase in the sharpness of the anode, they exhibit the following relations:—(1) Space AB—radiation No. 1 kindles the spark more intensively than radiation No. 2. (2) Point B—both radiations have an equal effect. (3) Space BC—radiation No. 1 kindles more feebly than radiation No. 2. (4) Point C—radiation No. 1 exhibits no effect, while No. 2 kindles. (5) Space CD—radiation No. 1 extinguishes, while No. 2 has still the opposite effect. (6) Point D—radiation No. 1 extinguishes; No. 2 exhibits no influence. (7) Space DE—both radiations extinguish, and in this case No. 1 is the more powerful in its effect. In the graphs the ordinates represent increase in volts (above), or decrease in volts (below), at the terminals of the primary coil of the transformer

(Fig. 1), brought about by the illumination of the spark-gap, and characterising the magnitude of its effect. The abscissæ relate to the number of revolutions of the regulator.

Many additional interesting facts are brought out by the author—such as those relating to the change of spark to arc, and to brush discharge, but for these reference must be made to the original paper. E. O. W.

1440. *Radiation of Electric Waves over Conductors and Semi-conductors.* M. Sjöström. (Jahrbuch d. Drahtlosen Telegraphie, 8. pp. 238-244, March, 1914.)—Discusses the theories of Sommerfeld and his school and the experiments of F. Erb. According to the latter attenuation of intensity is slower than $1/r^2$ for waves along plane metal surfaces, but faster than $1/r^2$ for waves along the surface of salt solutions. E. H. B.

1441. *Coupled Oscillatory Circuits.* Provotelle. (Lumière Électr. 25. pp. 647-651, May 28, 1914.)—A purely mathematical paper dealing with the solution of the equations of two coupled electric oscillation circuits. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1442. *Sensibility Curves for Selenium.* F. C. Brown and L. P. Sieg. (Phys. Rev. 2. Ser. 2. pp. 487-494, Dec., 1918.)—The sensibility curve for a Giltay cell has been determined under varying conditions. As is indicated by theory, it has been shown that long periods of exposure give varying degrees of complexity and are responsible for the regions of max. sensibility. By long periods of exposure a new maximum was obtained at 800μ . By exposures of a fraction of a second the maxima and minima vanish, and between about 460μ and 790μ the change of resistance is independent of the wave-length. The observations made show the importance of defining simple conditions for obtaining the maxima of an agent whose action is so complex as is that of Se. In the Giltay cell studied the maxima as well as the minima arise from the slow rates of change. A selenium cell of this type on account of the independence of wave-length for short periods of exposure may turn out to be the most delicate instrument constructed for measuring energy within the range noted. J. J. S.

1443. *Peculiarities of Compressed Powders of Antimony, Bismuth, and Galena.* G. Gehlhoff and F. Neumeier. (Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1069-1081, Nov. 15, 1918.)—The thermal and electric conductivity and also the thermo-e.m.f. per 1 deg. C. of compressed powders both of pure Sb and Bi and of Bi with small admixtures of Sb, were investigated. The specimens were examined at the temperatures -190° , 0° , and 100° and partially at -79° . Comparison is made with cast specimens at the various temperatures. The strong increase in heat conductivity with falling temperature observed in the case of specimens which have been fused, is much less marked with compressed powders. Mixed crystals are formed in only a small amount and the diffusion of the two metals into one another when the powders are mixed and pressed is very slow. The electric conductivity, especially of the compressed powders of the pure metals Sb and Bi, shows a distinct lessening in comparison with the cast metals. Pfeiderer's relation that thermal and electric conductivity decrease in equal proportion has no validity for mixed Sb and Bi. The earlier supposed relation that electric conduction finds

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smaller transition resistance than thermal conduction in compressed metallic powders is not established in the cases examined by the authors.

The result of the investigation shows that by means of the application of pressures up to 5000 kg./cm.² it has not been possible to obtain, with those metallic powders whose melting-points lie comparatively low (especially in the case of Bi), compressed blocks in which the formation of mixed crystals has resulted and whose physical characteristics resemble to a certain degree those of the fused metals.

J. J. S.

1444. Propagation of Electricity through Paraffin Oil. G. G. de Villemontée. (Comptes Rendus, 158. pp. 1414-1416, May 18, 1914.)—Oil of density 0.876 at 24° C. is placed between two concentric brass cylinders. The outer cylinder is maintained at a potential V , and the charge Q developed on the inner cylinder at various temperatures, t , is measured by a quadrant electrometer. The variations of Q/Vt are found to be similar at different times and for different durations of the exciting charge, and to be independent of the size of the cylinders. Up to potentials of 20 volts Q/Vt is represented by $ke^bt - a$, where k , a , and b are constants. The analogy between the conduction of the oil and that found for crystals by Curie is further substantiated.

C. S. G.

1445. Passage of Electricity through Paraffin. G. G. de Villemontée. (Comptes Rendus, 158. pp. 1571-1572, June 2, 1914.)—In continuation of previous experiments [see preceding Abstract] the author describes investigations of the laws governing the initial propagation of electricity through paraffin oil. The following results were obtained when the time of duration, θ , of the charge on the external cylinder was very short:—(1) the total charge received on the inner cylinder was found to be given by $q_1 = ke^b\theta^{-1}$, k and b being constants, and (2) the total charge received by the inner cylinder at any time, t , from the commencement of charge of the outer cylinder was given by $q_2 = ke^bt^{-1}$. These equations would seem to indicate an extremely great initial charge on the inner cylinder. Other interesting results were obtained. Two condensers of different dimensions were used to examine the effect of dielectric thickness. For charges of very short duration the total charges, q_1 , q_2 , of the above equations were found to be the same with both condensers. For charges of longer duration this did not hold, and when the time of charge was comparatively great (1 hr. 44 mins.) the ratio of the charges obtained on the inner cylinders differed very little from the inverse ratio of the dielectric thicknesses in the two cases.

J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

1446. Demagnetising Factors of Cylindrical Rods in High Fields. B. O. Peirce. (Amer. Acad., Proc. 50. pp. 58-64, June, 1914.)—Magnetic measurements on long rods cut down between successive observations lead to the following conclusion. In properly constructed solenoids with uniform fields above 2500 gauss, rods only 25 or 80 diameters long may be safely used with the expectation of finding that the fluxes through their meridian sections are the same, within the limits of ordinary careful laboratory practice, as if the pieces were infinitely long. At low excitations the corrections for the ends of pieces as short as this would, of course, be very large. The magnetising solenoid should be about 25 diameters of its own coil longer than the test-piece. [See also Abstracts Nos. 118 (1906), 676 (1908).]

G. E. A.

1447. *The Magnetic Properties of a Graded Series of Chrome Steels at Ordinary and Low Temperatures.* M. B. Moir. (Phil. Mag. 27, pp. 880-842, May, 1914.)—It is well known that the effect of raising the temperature of iron or steel is to increase its susceptibility to magnetism for low values of the magnetising force and to diminish it for high values. It is to be expected then that, if the temperature of a test-piece be lowered, the effect should be exactly reversed, and the susceptibility should be diminished for low, and augmented for high fields. That such is actually the case has been shown for various magnetic materials by Honda and Shimizu [Abstract No. 895 (1906)], and more recently by Gray and Ross [Abstract No. 259 (1913)], who have all used the temperature of liquid air, -190°C ., as the low temperature at which they have made their investigations. They have shown also that, while alike in this one respect, different materials differ very considerably both in the amount of change in susceptibility brought about by the change in temperature and in the value of the field strength for which the effect reverses its sign. In order to observe the effect of similar treatment on the different members of a graded series the magnetic properties at ordinary and low temperatures of a graded series of chrome steels were examined. The specimens were in the form of cylindrical rods 20 cm. long and 0.9 cm. diam., and the conditions in which they were tested were (1) forged and rolled, (2) annealed from 900°C ., (3) quenched from 900°C . In the first condition the specimen is in a state of internal strain brought about by the treatment to which it has been subjected in the course of preparation, and is in general far from homogeneous. The effect of annealing the specimen from 900° is to remove the internal strains, and to bring it into a standard homogeneous condition. Specimens are examined containing 1 %, 4.05 %, 8 %, 12 %, 16 %, and 20 % Cr. The results obtained are given in tabular and graphical form, and may be summarised as follows:—The effect of lowering the temperature of a chrome steel is to diminish its susceptibility for low fields and to increase it for high fields. The crossing of the curves at 15°C . and at -190°C . in the annealed condition takes place for higher values of the magnetising force as the Cr-content is increased up to 12 %, but further additions after that point lower the value of the field for which crossing occurs. Immersion in liquid air produces a permanent effect on the annealed specimen, which is not wiped out when the temperature is allowed to rise to room-temperature again. For specimens in the quenched condition the crossing of the curves at 15°C . and -190°C . occurs for very high values of the magnetising force, probably much greater than 100 C.G.S. units. Immersion in liquid air has no permanent effect on quenched specimens; and in both annealed and quenched conditions the residual magnetism and the coercive force are greater at -190°C . than at 15°C .

A. E. G.

1448. *Hall-effect in Flames.* H. A. Wilson. (Phys. Rev. 8, Ser. 2, pp. 875-881, May, 1914.)—From experiments by Marx on the Hall-effect in a Bunsen flame it appeared that the effect diminished as the conductivity of the flame increased, and varied with the nature of the salt sprayed into the flame. These results do not agree with the theory that the negative ions are electrons. The author gives a possible explanation of the discrepancy, and describes experiments which avoid the suggested sources of error. Current can be passed horizontally through a large flat flame in a direction perpendicular to the magnetic field in which the flame is placed. The Pt-electrodes are in the flame 9 cm. apart. The Hall-effect is measured by two horizontal Pt-wires, usually 1 cm. apart, connected to an electrometer. They are placed

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one above the other perpendicular to the flame, passing through it, fixed in a tube which, passing through a hole in the pole-face of the electromagnet exciting the field, is capable of rotation about a horizontal axis; the amount of rotation can be measured to 0.1° . With magnetic field off, the wires are turned until they are at the same potential, the electrometer being undeflected. With field excited, the wires are rotated through an angle θ until they are again at the same potential. Then $\tan \theta = X/Y$, where X and Y are the horizontal and vertical potential gradients in the flame. This ratio can be determined by one observation, knowledge of the electrometer sensibility being unnecessary.

The effect is independent of the current through the flame and hence of the horizontal potential gradient. It is also practically the same for flames with and without alkali metal salts. $\tan \theta/H$ is nearly constant, and the velocity of the negative ion per volt/cm. which by the usual theory is $10^8 \times X/HY = 10^8 \times \tan \theta/H = 2450$ cm./sec. Thus there seems no reason to doubt the conclusion that this velocity is the same for all alkali metal salts in a particular flame.

T. H.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1449. *Osmo-antikathodic Vacuum Regulator in Röntgen-ray Tubes.* C. Regaud. (Archives d'Él. Médicale, 22. pp. 600-609, June 10, 1914.)—This is a modification of that of Villard and Chabaud, and, like it, is based upon the property possessed by a thin lamina of Pt, of becoming permeable to hydrogen when heated to a suitable temperature. The principle of the modification is as follows: The osmo-regulating lamina of Pt is arranged as an antikathodic plate or part of such a plate, the hydrogen being made to pass over the exterior surface of the Pt; the necessary rise in temperature of the Pt is obtained as the result of the impact of kathode particles. The arrangements for obtaining this end are described in two sections: (1) Different arrangements of the antikathodic Pt lamina and of the system for circulation of the gas. (2) The antikathode as an emitter of Röntgen rays and as an osmo-regulator.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1450. *Colloidal Solutions of Radio-active Substances. II. F. Paneth.* (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1687-1651, Oct., 1913.)—The author has investigated the capability of dialysis, diffusion velocity, and direction of migration of several radio-active substances [see Abstract No. 580 (1914)], and it is shown that these properties depend on whether the observations are made in acid, neutral, or basic solutions. In acid solutions all dialyse with normal velocity, while in neutral and basic solutions the different radio-elements behave differently. The results show that polonium and RaE are colloids in neutral solution. ThB and RaD only begin to assume the colloidal state in ammoniacal solution, while Ra and ThX remain kathions in all cases. The colloid particles must be extremely small, an estimate of the molecular weight being 1600 in the case of Po and 460 in the case of ThB. The inclination to go into the colloidal state seems intimately connected with chemical nature.

E. M.

1451. *Action of Colloids on Radio-active Products in Solution. T. Godlewski.* (Phil. Mag. 27. pp. 618-632, April, 1914.)—In a previous paper [Abstract No. 1017 (1914)] the author showed that the products of the active deposit of Ra in neutral, alkaline, or weakly acid solutions are in the colloidal state. It was also found that in acidulated solutions or in presence of polyvalent kathions the products were deposited at the kathode almost exclusively, while in presence of polyvalent anions the anode is activated on electrolysis. Anomalous results were obtained with RaC which in pure water solution appears to be deposited partly at the kathode and partly at the anode, although RaA appears at the anode only and RaB at the kathode. Further experiments appear to give the explanation. When the atom of RaC arises from the RaB the recoil is only feeble, RaB emitting only a β -particle. For this reason if one of the atoms in the aggregate RaB which forms the centre of a positive hydrosol is transformed into RaC, it will not escape from its environment of RaB atoms, but will be carried with them to the kathode. We may therefore expect that only those RaC atoms go to the anode which during their transformation manage to escape, and also those which belong to groups in which the majority of the RaB atoms have already undergone transformation. The author has also made detailed experiments on the influence of foreign colloids on the hydrosols of RaA, B, and C. The results show that the addition of a negative colloid arsenious sulphide or Pt in small quantity, causes the products deposited at the kathode to diminish in amount and afterwards to disappear, *i.e.* it produces the precipitation of colloids of opposite signs. Similarly, positive colloids (ferric oxide) when added in relatively small amount conduce to precipitation of RaA and RaC which are among negative colloids; in higher concentrations positive colloids absorb them, thus inverting their signs. It is further shown that radio-active products, when present as positive hydrosols, can be concentrated by simple filtration since those hydrosols are entrained by filter-paper owing to capillary action.

E. M.

1452. *Combustion of Air in the Voltaic Arc. A. I. Gorbov and V. F. Mitkevitch.* (Russian Physico-Chemical Soc., Journ. 45. pp. 1109-1186, VOL. XVII.—A.—1914.

1918.)—The principal conclusions arrived at by the authors as a result of theoretical considerations and of experimental data obtained with a small Birkeland-Eyde furnace and with one of their own design, are as follows:—The relation between c , the percentage of nitric oxide formed on combustion of air under the influence of the voltaic arc, δ , the volume of air introduced into the furnace per hour per kw., and G , the number of gm. of nitric acid into which the nitric oxide may be transformed, is expressed by the equation $8G/225 = c\delta \dots (1)$, which is similar in form and in the significance of its terms, to the Clapeyron gas equation, $RT = pV$. From this it follows that (1) if with a given air-supply the conditions of combustion are changed so as to maintain a certain definite percentage of nitric oxide, the number of gm. of nitric acid per kw.-hour will be the greater the less the number of kw. supplied to the arc, and (2) one and the same quantity of nitric acid per kw.-hour may be obtained with various concentrations of nitric oxide, if with constant arc-power and variable conditions of burning the percentage of nitric oxide changes in inverse proportion to the air-supply.

The general relationship between the air-supply and the percentage of nitric oxide in the issuing gas may be derived *a priori* on the assumption that the divergence of technical apparatus from the ideal is expressible as a certain air-supply to be applied as a correction to that actually used. The conclusion thence drawn is that, with the limits in concentration of nitric oxide as yet attainable in practice, this relationship is expressed by the hyperbolic formula $c = b/(\delta + a) \dots (II)$. Writing b' for b/a , this gives $G = 225a(b' - c)/8 \dots (III)$ and $G = 225b\delta/8(\delta + a) \dots (IV)$. These equations are regarded as general, and are probably applicable to the data obtained with any electric furnace. Comparison of equation (III) with the fact that a furnace may work with a constant yield of nitric acid, but with a variable percentage of nitric oxide, leads to the conclusion that, for each furnace, there is possible not a single equation of type (III), but a series of them corresponding with varying utilisation of the energy. In agreement with the observations of other investigators, it is found that the values of a' and b' , a'' and b'' , etc., for this series of equations exhibit a constant ratio, that is—

$$b''/a'' = b'''/a''' = \dots = \text{const.} = b'.$$

In the diagram representing the values of G as ordinates and the corresponding ones of c as abscissæ, each furnace is represented by a group of straight lines beginning in the point b' and spreading upwards from right to left in the shape of a fan. The constancy of b' does not follow immediately from the above equations, but is found to be in agreement with the fundamental hypothesis expressed by $c = b/(\delta + a)$. A further conclusion drawn from the experimental data is that the concentration of nitric oxide on breaking of the arc is independent of the power of the arc, and almost independent of the detailed construction of the furnace, although characterised by its type; such a conclusion is, however, based on a comparatively small number of results.

The magnitudes of b and b' are regarded as characterised principally by the density of the energy in the region where the nitric oxide is formed, and the technical plant now in use leaves considerable room for increasing them; the magnitude of a should be as small as possible.

T. H. P.

1453. *Influence of Various Conditions on the Oxidation of Nitrogen in the Voltaic Arc.* A. V. Schaposchnikow, A. Gudima, and V. Kutovski.

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(Russian Physico-Chemical Soc., Journ. 45. pp. 1076-1091, 1918.)—Experiments made with an arc passing between carbon electrodes show that, as the air-supply, V (cub. m. per hour), is increased, the ratio of V to the power consumed, KW, also increases. The yield of nitric acid per kw.-hour at first increases to a maximum of 65.8 gm. for $V/KW = \text{about } 1$, then diminishes somewhat, and finally increases again to 78 gm. per kw.-hour for a value 1.90 of the ratio V/KW . With both dry air and air saturated with moisture, the percentage of nitric oxide in the issuing gases increases to a maximum, and then decreases as the air-supply is continuously increased, but the wet air gives the higher yields in all cases, the difference in yield diminishing as the air-supply increases. The action of the moisture is probably expressed by the equations: $N_2 + 2H_2O = 2NO + 2H_2$ and $2H_2 + O_2 = 2H_2O$.

As material for the electrodes, carbon is greatly to be preferred from an industrial point of view. It gives a very constant arc, requires no cooling arrangement, and allows of the ready introduction into the arc of extraneous substances; it burns away rapidly, but this may be avoided by coating the lateral surfaces electrolytically with nickel. Of metallic electrodes, those of copper give the best results, whilst the use of Pt is not to be recommended.

T. H. P.

1454. Fixation of Atmospheric Nitrogen by Means of Boron Compounds. I. A. Stähler and J. J. Elbert. (Ber. Deut. Chem. Gesell. 46. pp. 2060-2077, 1918.)—The object of the authors' experiments was to determine the conditions under which boron nitride may best be obtained from naturally occurring compounds of boron. Since in such compounds the boron is generally combined with oxygen, it was necessary to investigate first the best methods for their reduction and then the combination with nitrogen of the boron or boride formed. The reduction of boron trioxide by carbon begins to take place at 1200° ; in the presence of nitrogen, calcium borate (borocalcite) undergoes reduction at 1280° , reaction probably taking place according to the equation: $CaB_4O_7 + 8C + 8N_2 = 4BN + CaCN_2 + 7CO$.

The electrolysis of molten borax gave yields of boron to the extent of 12.1 %. Carbon electrodes were first used, but they broke off repeatedly at the surface of the fusion; iron electrodes lasted longer, but they also broke off after a time. Attempts to reduce boron trioxide by means of calcium carbide at 1625° made it probable that the product of reaction was calcium boride, which has previously been prepared by Moissan.

Before carrying out further experiments on the production of boron nitride it was necessary to determine its stability; it was found that decomposition with evolution of nitrogen only commenced to take place at 2450° ; this temperature of decomposition holds only in the presence of carbon, since the boron nitride was contained in a graphite crucible.

The next experiments were confined to mixtures of carbon with either boron trioxide or borocalcite. These were heated to different temperatures in an atmosphere of nitrogen under different pressures, a special electrical furnace having been constructed in which reactions could be carried out at pressures up to 500 kg./cm.², and at temperatures up to 2500° . With mixtures of boron trioxide and carbon and nitrogen at atmospheric pressure, the best yield, 26-28 % of boron nitride, is obtained between 1600° and 1700° . With increasing pressure the yield increases, more than 85 % of boron nitride being obtained at a pressure of 70 kg./cm.² and a temperature of 1600° . When the boron trioxide is replaced by borocalcite, a nearly theoretical yield of boron nitride, according to the equation given above, is obtained when the

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temperature is maintained at 1850° for 80 minutes and 1400° for 15 minutes ; increase in pressure of the nitrogen has no effect on the yield. At normal pressures the amount of nitrogen absorbed per gm. of boron is much greater with borocalcite than with boron trioxide ; only at very high pressures are better results obtained with boron trioxide than with borocalcite. T. S. P.

1455. Ageing of Alloys of Silver and Tin. W. A. Knight. (Chem. Soc., Journ. 105. pp. 639-645, March, 1914.)—The ageing of the alloy Ag₃Sn is not accompanied by increase in weight and is not produced by the action of either ozone or an acidified concentrated solution of hydrogen peroxide, so that it cannot be regarded as due to superficial oxidation. The phenomenon is not prevented by the presence of Mg in the alloy, whilst grinding in an agate mortar neither ages the unaged filings nor renders aged filings unaged. Hydrogen sulphide is without action on the weight of the alloy or its capacity to absorb mercury. The presence of an admixture of tin or silver with the alloy diminishes the difference between the aged and unaged alloys as regards the amounts of mercury they retain. When heated at 100° in coal-gas the alloy is completely aged in 20 minutes. Dilatometric measurements show that the volume of the alloy decreases by about 0.4 per cent. during ageing.

T. H. P.

1456. Alloys of Aluminium and Silicon. C. E. Roberts. (Chem. Soc., Journ. 105. pp. 1888-1896, May, 1914.)—Reinvestigation of the thermal diagram of the Al-Si alloys in order to determine the possibility of the existence of either a compound of the two elements dissociating at high temperatures or an allotropic modification of Si stable above 1200°, results in complete confirmation of W. Fraenkel's statement that the alloys form a simple eutectiferous series, the eutectic melting at 578° [see Abstract No. 1824 (1908)]. That no compound is formed is supported by the observation that no silicon hydride could be detected when the alloys were dissolved in acids, and the plotted eutectic arrests confirm this conclusion. Microscopic study of the structure of the alloys is in accord with these results.

T. H. P.

1457. Second Report to the Corrosion Committee of the Institute of Metals. G. D. Bengough and R. M. Jones. (Inst. of Metals, Journ. 10. pp. 18-91 ; Discussion and Communications, pp. 92-118, 1918. Engineering, 96. pp. 299-305, Aug. 29, and pp. 889-842 ; Discussion, pp. 812-814, Sept. 5, 1918.)—The points of interest deduced from the answers of engineers and others interested in condensers, to the schedule of questions drawn up by the Corrosion Committee are (1) the enormous variation in the life (4 to 25 years) of tubes even from the same batch of material, (2) the peculiar nature of the deterioration which was in nearly every case brought about by dezincification, (3) the impossibility of correlating corrosion with the presence or nature of the electric light installation, (4) the difficulty of connecting corrosion with any definite locality in the tube or condenser, and (4) the shorter life of tubes in land installations using canal, dock, or brackish water instead of sea water. The scale often exists in layers with no sharp line of demarcation between them ; the upper layer consists of ferric oxide, carbonates, chloride and sulphates of lime, and magnesia and sand ; the intermediate layer is composed of carbonates and chlorides of zinc and copper, while the lower layer which adheres strongly to the tube consists of cuprous and cupric oxides. In a dezincified tube the greenish-blue middle layer is replaced by a white flocculent basic chloride of zinc. In no case could dezincification be traced to carbon deposits. Corrosion phenomena may be divided into two classes :

(1) complete corrosion in which the tube is gradually worn down by removal of the copper and zinc in the proportions in which they exist in the alloy ; (2) selective corrosion or dezincification in which the zinc is removed preferentially and locally. The latter is the more common type of failure in practice. The whole subject has been studied by tests made in sea water on tubes of 70 : 80 brass, a special brass (70 % Cu, 28 % Zn and 2 % Pb), Muntz metal (61 % Cu, 39 % Zn), and Admiralty brass (70 % Cu, 29 % Zn and 1 % Sn), both in the laboratory and in an experimental condenser plant.

In the laboratory the following points were taken into account : (1) the volume, temperature, and concentration of the corroding medium ; (2) the mode and depth of immersion, (3) the rate of diffusion, (4) the area of metal exposed, and (5) the surface condition of the metal. In stagnant sea water at the ordinary temperature corrosion is always of the complete type, is very slow and decreases in rate with the progress of time. It appears that dissolved oxygen first forms a superficial film of copper and zinc oxides on the surface of the metal. These are dissolved by the CO_2 and NaCl , but the whole of the copper and the greater part of the zinc are immediately precipitated, usually as a flocculent basic chloride and carbonate, while part of the zinc remains dissolved as chloride. Circulation and increase in the concentration of the sea water increase the rate of corrosion, while decrease in the concentration decreases the rate of corrosion and, after prolonged exposure, alters its type. The presence of flaws and spills, contact with particles of coal, coke, graphite, sand and basic deposit, etc., have little or no effect on the nature and rate of corrosion. Muntz metal shows the greatest resistance to complete corrosion, Admiralty brass the least, while the other two alloys are about equal and intermediate. Tests made at higher temperatures showed that temperature is the predominating influence in determining the type of corrosion. At 40°C . selective corrosion occurs as well as general corrosion, but at 50°C . the corrosion is almost wholly selective. Selective corrosion is accompanied by the formation of basic zinc chloride which settles and adheres to rough parts of the tubes and intensifies and localises the action, resulting in pitting. Dilution increases, and concentration decreases, the tendency towards dezincification, while the presence of particles of foreign matter with the possible exception of zinc chloride and hydrate has little or no effect. There is no relationship between loss in weight and degree of dezincification, since Muntz metal loses the least in weight and is subject to the greatest dezincification, of the four alloys. Admiralty brass resists dezincification almost completely at 50°C . owing to the powerful protective effect of tin. There is evidence to show that selective corrosion only occurs over a range of temperature. Experiments in the condenser plant corroborated the results of laboratory tests. In the plant, 48 condenser tubes were subject to conditions similar to those ruling in the mercantile marine for 9 hours per day for 9 months. The plant was closed down every night, Saturday afternoon and Sunday. The sea water used contained 8.19 % total chlorides, which increased to 4 % in about 6 weeks, when the sea water was changed. Subsequent examination of the tubes showed that the Admiralty brass and the 70 : 80 brass were most resistant and the Muntz metal least resistant. In all cases attack was most severe near the centre of the tubes where the steam enters the condenser, showing the important influence of temperature. Corrosion occurs most frequently along the bottom of the tubes. Dezincification appears to be inherent in alloys of the brass type and increases with the zinc-content. Electrochemical protection has also been

studied and has been traced to the precipitation of calcium carbonate as a firmly adherent deposit by electrolysis of the bicarbonate. This explains how a protective action is exerted at great distances from the anodes.

With regard to the practical problem it is recommended that the best methods of hindering dezincification are by the abandonment of the use of plain brasses and substituting alloys of the type of the special brasses containing tin or lead. In addition, the temperature in the condenser should be carefully controlled, and the use of electrochemical protection considerably extended.

F. C. A. H. L.

1458. *Bronze*. J. Dewrance. (Inst. of Metals, Journ. 11. pp. 214-228; Discussion, pp. 224-284, 1914. Engineering, 97. pp. 405-406, March 20, 1914.)—Gives the results of tensile tests taken at various temperatures up to 700° F., on bronze containing copper 88, tin 10, zinc 2, and also copper 87·5, tin 10, zinc 2, lead 0·5 %. In the case of the alloy without lead there is a considerable decrease in strength as the temperature of the test is increased, whereas in the case of the alloy containing lead no serious decrease is noted until a temperature of 500° F. is exceeded.

C. O. B.

1459. *Influence of Phosphorus on some Copper-Aluminium Alloys*. A. A. Read. (Inst. of Metals, Journ. 10. pp. 844-868, 1918. Mech. Eng. 82. pp. 444-447, Nov. 7, 1918. Abstract.)—After a few preliminary tests, it was decided to thoroughly examine the effect of phosphorus on copper alloys containing 5 % and 10 % Al. With the alloys containing 10 % Al, only about 0·2 % P can be added; with above this amount, a metal is obtained which on filing or turning gives off an odour of phosphine due to the decomposition of aluminium phosphide. The effect of very small quantities of P on annealed samples is to raise the yield-point a little and to increase the elongation and reduction of area considerably, while the maximum stress remains practically the same.

A much larger amount of phosphorus can be added to the 5 % Al alloys: the bars containing 1 % P were worked without the slightest trace of phosphine being detected. On annealed samples, the yield-point and max. stress rise a little and the reduction of area is lowered as the P increases.

In chill castings, with increasing P the yield-point rises continuously and the ultimate stress attains a maximum at 0·52 % P, but the elongation and reduction of area fall rapidly. The results of alternating stress tests are given which show the detrimental effect produced by annealing the 10 % Al alloys. Hardness tests obtained by the Shore scleroscope and the Brinell method are also given. The relative hardness numbers recorded by the two methods are in fairly close agreement, and show that in the 10 % Al alloy, with the small increasing amounts of P, the hardness of the annealed bars is unaltered, but with the cold-drawn bars the hardness is raised slightly. With the 5 % Al alloys, small additions of P do not alter the hardness of the annealed bars, but in the chill castings a considerable increase in hardness is obtained after 0·25 % P is passed.

Results of tests for electrical conductivity are given which show that the conductivity of the 5 % alloy is only very slightly greater than that of the 10 % alloy. The effect of P is to diminish the conductivity in both cases, but with the 5 % alloy the diminution is much more marked, being with the same amounts of P more than twice as great as in the 10 % alloy. The presence of P is found to lower the melting-points of both series of alloys.

A number of corrosion tests were carried out and the results show that a

pure fresh water had an exceedingly small action on the alloys, while in the case of sea water the effect of small quantities of P is to reduce the loss of weight due to corrosion.

The solubility of P in copper is found to be increased by the presence of Al. C. O. B.

1460. *Critical Ranges, Physical Properties, and Microstructure of Manganese Steel.* W. S. Potter. (Amer. Inst. Mining Engin., Bull. 88. pp. 601-628, April, 1914.)—Heating curves of manganese steel showed well-defined retardations at 850-875° C., 1100-1140° C., and at 1200-1210° C., while slight retardations were recorded at 850-875° C., 450-475° C., 575° C., 875-785° C., 975-1025° C. Cooling curves showed well-defined retardations at 850-825° C., 1125-1060° C., 1200-1170° C., and slight retardations at 1080-1020° C., 950-925° C., 710-650° C., 550-525° C., 450-420° C., and at 850-825° C. The melting intervals occurred between 1850° and 1875° C., and the freezing intervals between 1870° and 1275° C., according to the composition of the alloy. Experiments have also been made with a view to determining the effect of heat-treatment on the strength and ductility of the alloys. Prolonged soaking at high temperatures followed by quenching at a lower temperature decreases both strength and ductility. The max. strength and ductility was exhibited by a specimen quenched from 815° C., while the minimum strength is shown by alloys quenched from about 650° C. Microscopic study of the alloys containing 9-20 % Mn and 1-2 % carbon showed that the structural constituents were γ -iron or austenite, cementite, a double carbide of manganese and iron, a eutectic of cementite and austenite, and a eutectic of lamellar structure. In addition, martensitic, troostitic and sorbitic structures were met with. Between 1870° and 1270° C. γ -iron freezes out, while the eutectic separates at 1125° to 1080° C. The mechanical break-up of austenite begins at 850-825° C. At 710-650° C. carbides separate between the grains. Magnetism increases between 550° and 525° C. and is accompanied by further carbide separation. During heating of originally austenitic steel there is a preliminary break-up at 850° C., which is continued at 450-470° C. and completed at 575° C. Magnetic carbides of iron and manganese separate at 475° C. and at 575° C. In rolled steel, solution of carbides begins at 725° C. and is completed at 850-870° C. with the re-formation of austenite. F. C. A. H. L.

1461. *Structural Changes of Iron during Annealing.* D. Ewen. (Int. Zeitschr. Metallg. 6. pp. 1-16, March, 1914.)—When polished specimens of metals are heated *in vacuo*, network patterns are produced on the polished surface.

In the case of wrought iron, three distinct types of heat relief have been obtained corresponding to initial α and β -iron structure, γ -iron structure, and final β and α -iron structure. By means of tests at various temperatures, these structures have been attributed to allotropic changes in the iron. The development of the α -iron heat relief structure on heating has been ascribed to selective volatilisation from the crystal boundaries. The γ -iron heat relief and the final β - and α -iron heat relief obtained on cooling may be attributed to differences in dilatation of the allotropic modifications involved. The etching effect obtained above A_{r_1} , especially where the metal is heated by the direct passage of a heavy current through it, probably results from a species of electrical disintegration.

It is shown that these networks or "heat-relief" patterns may be taken as truly expressing the crystalline structure of the metal at various temperatures. [See also Abstract No. 762 (1910).] C. O. B.

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1462. Embrittling of Iron by Caustic Soda. J. H. Andrew. (Faraday Soc., Trans. 9. pp. 816-829, March, 1914.)—Microscopic examination of an iron tube which had become extremely brittle during use in a caustic soda concentrator showed large crystals and an intercrystalline fracture. The cell walls were very thick and the grains themselves showed peculiar markings. Experiments on the corrosion of polished and unpolished specimens of wrought iron and 0.5 % carbon steel in hot concentrated caustic soda showed that wrought iron is corroded more rapidly than steel. The rate of corrosion diminishes with the time. After a short time the steel becomes coated with a black deposit which also ultimately makes its appearance on the wrought iron, but after a much longer time. This deposit is most probably Fe_3O_4 , and ultimately converts the loss into a gain in weight. Polished specimens corrode less rapidly than unpolished specimens, either because of the lower solubility of the amorphous phase in caustic soda or because of the uniformity of surface preventing electrolytic action. A white precipitate formed during the tests was found to consist of silica and sodium ferrate. Evolution of gas occurred, and the gas evolved was proved to be hydrogen. During the first few weeks the grains of the wrought iron were observed to grow and the metal became extremely brittle. After a further period, however, malleability was restored. These recrystallisation effects have been attributed to the absorption of hydrogen. It has been shown previously that amorphous metals occlude hydrogen much more rapidly than crystalline metals do. On this basis it appears probable that hydrogen is rapidly absorbed by the intercrystalline amorphous phase. It diffuses along the paths occupied by this phase and forces apart the allotriomorphic grains. When the concentration of the hydrogen reaches a certain limit, diffusion takes place into the crystalline phase, sets up mechanical disturbances, and probably causes recrystallisation. These two hydrogen-saturated phases produce a hydrogen cell, their potential differences are thereby lowered and the electrolytic corrosion is reduced. The passivity of iron produced by immersion in caustic soda can be explained on similar lines. Previous saturation with hydrogen is also found to reduce the rate of corrosion. The author suggests that the crystallisation of electro-deposited iron as it cools through Ar_2 is due to the evolution of hydrogen. F. C. A. H. L.

1463. Nitride of Iron. G. Charpy and S. Bonnerot. (Comptes Rendus, 158. pp. 994-996, April 6, 1914.)—When subjected to the action of ammonia at a red heat the surface of a piece of iron or steel begins to harden, then fissures are produced, and finally exfoliation takes place, resulting in the formation of small particles of Fe_3N . Small shavings of iron are readily and completely converted into nitride. The rate of formation is slow below 500°C . and increases with rise of temperature. At the same time the formation is governed by the inverse reaction, i.e. reduction of Fe_3N by hydrogen, so that it is necessary to increase the rapidity of the current of ammonia as the temperature rises: the most favourable conditions are observed between 650° and 700°C . The reduction of Fe_3N by hydrogen commences a little below 850°C . and attains a max. rate between 500° and 600°C . In nitrogen at atmospheric pressure decomposition begins at just above 850°C . Decomposition is complete above 600°C ., but experiments below 600° indicated the existence of a nitride, Fe_4N , more stable than Fe_3N . Pressure reduces the rate of decomposition, but even a pressure of 18 atmos. will not cause the direct combination of iron and nitrogen. From the experiments made it does not appear possible that iron nitride can exist in iron or steel produced
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industrially. The small amount of nitrogen present in such products must either exist in the free state or in combination with some element other than iron.

F. C. A. H. L.

1464. Thermal Expansion and Rate of Solution of Iron-Carbon Alloys. J. Driesen. (Ferrum, 11. pp. 129-188, Feb., and pp. 161-169, March, 1914.)—Experiments have been made on the thermal expansions between 20° and 1000° C. of fairly pure iron-carbon alloys containing 0.05 to 8.9 % C, in both the annealed and quenched conditions. This study has been extended by determining the rate of solution in N/10 sulphuric acid solution of quenched, tempered, and annealed alloys. Up to 500° C. heating and cooling curves were identical within the limits of experimental error, but above this these curves did not coincide and the bar appeared to have undergone a permanent change of length. On the curves showing changes of length with temperature, irregularities are observed at 180° C. which are ascribed to a transformation in the cementite: α cementite (stable below 180° C.) has a lower coefficient of expansion than β cementite, whose coefficient is about equal to that of ferrite. The method can be used for determining the critical points of the iron-carbon alloys, giving results which agree with those obtained by other methods. There is, however, no definite indication of the α - β change. With normal rates of heating and cooling the pearlite change-point occurs at 789° C. on heating and 707° on cooling. Extremely slow cooling gives a higher value for the A_{r1} . In alloys containing over 0.85 % C the coefficient of expansion is approximately constant above the change-point. As a function of concentration in the same alloys the coefficient of expansion shows a well-defined maximum at 1.7 % C. A max. change of length in the transformation range is observed at a concentration of 0.88 % C. Quenched steels show a contraction at 275° to 840° on tempering, and in alloys with over 1 % C another contraction is observed at 100-150°. The rate of solution of hardened steels shows a well-defined minimum on tempering at 170° and a maximum after tempering at 850-420° C. Curves showing the relationship existing between rate of solution and carbon-content of hardened steels tempered alike exhibit discontinuities in the neighbourhood of 0.9 % C. F. C. A. H. L.

1465. Influence of Nickel on some Copper-Aluminium Alloys. A. A. Read and R. H. Greaves. (Inst. of Metals, Journ. 11. pp. 169-207; Discussion, pp. 208-218, 1914. Engineering, 97. pp. 399-404, March 20, 1914.)—Contains the results of an investigation of the influence of nickel on copper-aluminium alloys containing 5 % and 10 % of Al. The triple alloys examined in each of the two series contained from 1 % to 7 % of Ni. The effect of Ni on the rolling properties is recorded, and this is followed by results of wire-drawing tests and tensile tests. A summary is given of the effects of Ni on the mechanical properties of chill-castings, annealed rods, cold-rolled bars, quenched bars, and air-cooled bars of the two series.

Alternating stress tests carried out on the Arnold machine are described, and also the results of hardness tests by the Shore scleroscope and the Brinell method.

The melting-points as determined by a thermoelectric pyrometer and electrical resistance of annealed and quenched wires are given. The results of corrosion tests carried out in sea water and in fresh water and the results of microscopic examination are also included. C. O. B.

1466. Osmotic Pressure and Moist Air. W. D. Bancroft. (Journ. Phys. Chem. 18. pp. 67-69, Jan., 1914.)—The author quotes from the Journal of the VOL. XVII.—A.—1914.

Chemical Society for 1854 three cases in which casks of molasses housed in a damp warehouse had imbibed water apparently by osmotic pressure against moist air instead of against liquid water. In one case, apart from much loss by bursting of the barrels, a gain of weight of $28\frac{1}{2}$ cwt. on 1270 cwt. was recorded, in another 56 cwt. on 4160 cwt.; in a third case 6.8 galls. of water (68 lbs.) were found to have been drawn into one cask during 8 $\frac{1}{2}$ years.

T. M. L.

1467. *Flame Reactions*. II. W. D. Bancroft and H. B. Weiser. (Journ. Phys. Chem. 18, pp. 281-336, April, 1914.)—Further experiments [see Abstract No. 1005 (1914)] lead to the following conclusions. An absolutely transparent gas will emit no light at any temperature unless some reaction takes place. A coloured vapour may emit a purely thermal luminescence, but this does not prove that the actual luminescence in any particular case is entirely thermal. The fact that the luminescence of a moderately transparent vapour has a lower intensity than the corresponding luminescence of a black body at the same temperature is not necessarily a proof of thermal luminescence. There seems to be no justification for the assumption that temperatures of about 6600° and 7200° are reached in the hydrogen and carbon monoxide flames respectively. The statement that a candle flame will melt platinum but will not melt sodium chloride is inaccurate. Since the luminescence of any given flame may be due wholly or partly to chemiluminescence, it is important to determine the reactions occurring in the flame and to what extent the luminescence is due to these reactions. In the study of flame reactions, distinction must be made between colours due to emission and those due to absorption.

Study of the flame reactions of tin and its salts shows that the conversion of tin to stannous salt is accompanied by carmine luminescence and that of stannous salt to stannic salt by green and usually more intense luminescence. The reactions which produce these are mainly $\text{Sn} \rightarrow \text{Sn}^{++}$ and $\text{Sn} \rightarrow \text{Sn}^{+++}$, but it is unknown what luminescence is due to the conversion of stannous or stannic ion into the corresponding undissociated salt; no characteristic luminescence has yet been detected for the reverse reactions. The differences between the spectra of tin chloride, bromide, and iodide are due to the absorption spectra of the halogens and the salts and to the light emitted by the reactions of the halogens themselves.

The conversion of copper to cuprous ion is accompanied by a green, that of cuprous ion to cuprous salt by a red, and that of cuprous ion to cupric salt by a blue, luminescence; it has not yet been determined what luminescence is due to the conversion of cupric ion to cupric salt. The intensity of the green luminescence is so great that the unaided eye does not notice any blue in the ordinary copper flame even although the copper burns chiefly to cupric salt; no characteristic luminescence has been detected for the reverse reactions. Undissociated cupric chloride vapour has a violet-red colour, but this must not be mistaken for luminescence.

T. H. P.

1468. *The Theory of Adsorption*. A. Eucken. (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 845-862, April 15, 1914.)—On the assumption that gas adsorption on a solid body represents the formation of a layer of compressed gas owing to physical forces of attraction, the author deduces formulæ for the adsorption of an ideal gas. It is found that, in harmony with experiment, the absorbed amount is, for low pressures, proportional to the gas pressure. The formula also in general reflects well the dependence of adsorption on temperature. In the case of a real gas saturation of the surface takes place

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at high compression owing to the diminution of the compressibility. In the case of the adsorption of a vapour, saturation can, as a rule, be effected only on a strongly pitted surface, and not on a smooth surface. A. F.

1489. *The Critical Point, and the Significance of the Quantity b in the Equation of van der Waals.* T. W. Richards. (Amer. Chem. Soc., Journ. 86, pp. 617-684, April, 1914.)—In a discussion of the above point, the author points out: (1) The value of b in carbon dioxide must be admitted to vary according to conditions in such a way that, although fairly constant under moderate pressures, it diminishes greatly with very high pressures. (2) The value of b in hydrogen and CO_2 is probably affected by temperature, the nature of this effect being dependent on the value assumed for a . Both of these probabilities seem to be accepted by van der Waals himself. (3) The value of b with the monatomic gas helium is found to have a decidedly negative temperature coefficient. (4) This decrease in b with rising temperature seems to imply that the helium atoms are compressed by collision, the greater compression taking place at higher temperatures because of the greater kinetic energy of collision. This conclusion suggests further that uncombined atoms are not expanded by rise of temperature—a conclusion in keeping with the solely translatory effect of heat on monatomic gases. (5) In polyatomic molecules this effect may be supposed to be partly counteracted by some sort of expansion of the molecule due to the energy expended within the molecule, as indicated by the larger specific heat of polyatomic molecules. (6) Therefore, since b may be supposed to be a function of the actual size of the molecules, one is driven to conclude that molecules may change the effective size which they assume under collision. (7) If the atoms and molecules are thus compressible, van der Waals' conclusion that b is equal to four times the actual molecular bulk falls to the ground; one must assume that the molecules really occupy considerably more space. It is not unreasonable to imagine that the actual molecular bulk (when the molecules are not compressed by collision or cohesion) is probably even larger than b , perhaps about the critical volume. (8) It is pointed out that as a matter of fact b occupies very nearly the bulk of the corresponding liquid at a temperature somewhat above the boiling-point in many cases. This again shows that in the state of gas, when not compressed by cohesion, the molecules must be somewhat larger than b . (9) The approximate, although often unsatisfactory, agreement of the equation of van der Waals at the critical point is perhaps less significant than is usually imagined: the continuity between the liquid and the gaseous states may be supposed to exist only at the critical point. (10) The critical temperature is defined by supposing that it is the point where the kinetic energy of the molecules is just barely enough to separate them when the outside pressure is sufficient to bring, on the average, the molecular surfaces into contact. Therefore the critical volume may be about the true volume of the non-cohesing molecules, as stated above. (11) From these conclusions it is evident that the theory of compressible atoms affords a satisfactory explanation for the inadequacy of the equation of van der Waals, and the equation of corresponding states derived from it. The latter equation would be expected to hold better than the former, because the same kinds of deviations often exist in different gases, and the method of comparison may eliminate these. A. F.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1914.

GENERAL PHYSICS.

1470. *Improved Form of Integrator.* J. G. Johnstone. (Inst. Engin. and Shipbuilders, Trans. 87. pp. 14-27 ; Discussion, pp. 28-36, April, 1914.)—The instrument here considered is of the kind in which a pointer is moved over the boundary of an area to be measured or integrated, and in which the "area" and "moment" are recorded by means of small wheels which roll and slide over the surface containing the given area. Full details are given of the instrument and method of use. A simple theory is also given. Applications are made to (i) the integration of the body plan of a vessel's form in order to obtain the displacement curve ; (ii) integrating a body plan of a vessel's form in order to obtain the displacements and moments for cross curves of stability. In the *discussion*, *Scribanti* gave a more complete theory of the instrument, showing that the use of the instrument would give only approximate results. The correction terms are discussed, and it appears that in spite of the neglect of these in the original paper, the instrument constitutes an advance on other integrators, one point rendering it particularly valuable for some purposes being that it is unnecessary with this instrument to trace completely round an area. A. W.

1471. *Optical Torsion Dynamometer.* V. Vieweg. (Zeitschr. Vereines Deutsch. Ing. 58. pp. 1016-1018, June 20, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—Diagrams and description are first given of a torsion dynamometer due to *Amsler*, in which a stroboscopic method of determining torsion is employed. In the second instrument dealt with, a lens system, with its axis parallel to the shaft, is carried by a disc (C) concentric with the shaft and carried by a tube connected at its farther end to the shaft. This disc (A) is situated at a distance from the end of the tube equal to the focal length of the lens system, and this end of the tube carries a second disc (B) with a scale which can be viewed through the lens. A second scale is carried by another disc (C), nearly touching disc (B), and secured to the end

of a tube similar in all respects to the first, and attached at its other end to the shaft. A source of light illuminates the scales, and the difference of the readings when stationary and when under torsion is a measure of the torsion on the length of shaft between the points where the tubes are attached. [See also Abstracts Nos. 1042 (1918), 641 (1914).] A. W.

1472. Modifications of a Balance for Ease and Quickness of Weighing. G. A. **Shakespeare.** (Phil. Mag. 27. pp. 990-994, June, 1914.)—In the use of a good physical balance the accuracy of weighing is mainly limited by (a) the accuracy of the weights, (b) constancy of temperature in the balance case, (c) the accuracy with which the position of the rider can be read, and (d) the magnitude of the smallest measurable deflection of the beam. Frequently details (a) and (b) are not sufficiently regarded. Theoretically, the sensitiveness may be increased so that the smallest appreciable change of position of the rider produces an observable deflection of the beam. In practice, however, it is found advisable to have a degree of sensitiveness for which a comparatively large change of position of the centigramme rider produces no appreciable change in deflection. In other words, the rider is usually too small and the means of measuring deflection not sufficiently delicate. In the balance described the rider is therefore comparatively large (either 0.5 or 0.05 gm.), and the deflection is observed optically by using a concave mirror attached to the beam. The rider beam runs from end to end of the beam, the upper edge being in the plane of the knife-edges. It is divided into ten equal divisions, each of which is subdivided into ten smaller divisions. The rider is in the form of an elongated ring which surrounds the rider beam, and is provided with a hook at its upper part. The rider is moved by means of a thin silk cord passing through a slit at each end of the balance case. The lower part of each slit slopes downwards and forwards, the upper part being vertical and in the same plane as the rider beam, but rising above the level of the top of the rider. Small weights at each end of the cord keep it clear of the beam when not required to move the rider. The effect of using the concave mirror is to provide a pointer of considerable length but with small mass and moment of inertia, so that the period of oscillation is appreciably reduced. There is, moreover, no parallax. In weighing, the weights are placed in the right-hand pan, the rider being at its zero mark at the left-hand end of the beam. Weights to the nearest gramme (less than the weight of the body) are put into the pan if the $\frac{1}{2}$ -gm. rider is used; the case is closed, and the fractions of a gramme are given by one setting of the rider. A balance fitted in the manner described has been found to give great saving of time and labour in weighing. A. W.

1473. An Instrument to Measure Wind-pressure. Giessen. (Zeitschr. Vereines Deutsch. Ing. 58. pp. 886-840, May 28, 1914.)—By using the instrument described it is possible to obtain a continuous record of the resultant wind-pressure exerted upon any object, including the suction effect on the lee side, and also the line of action of the pressure. The instrument consists essentially of an upright bar on the top of which the object to be investigated is mounted. The bar is supported in a way fully described in the original paper, whereby the forces required to keep it in the vertical when the object fixed to the bar is exposed to the wind can be accurately and automatically recorded. The magnitude and line of action of the resultant pressures are not recorded directly—they have to be computed from a number of force curves treated collectively. R. C.

1474. *Report of the National Physical Laboratory for 1918.* (Engineering 97. pp. 881-882, June 26; 98. pp. 27-31, July 8, and pp. 74-77, July 17, 1914.)—A radium testing department has been opened and the establishment of a radio-telegraphic research laboratory is under consideration. Wind-pressure investigations with stiffer diaphragms on the high-level girders of the lower bridge show that wind pressure on a structure in a uniform current can be predicted by taking the mean of a sufficient number of observations in the open air. Appliances for testing the efficiency of power transmission through gear boxes have been designed and built for the War Office Mechanical Transport Committee. The speed range is from 87 to 1000 r.p.m.; influence of temperature and extent of oil-filling are under investigation. Important investigations are in progress concerning fluid friction in pipes (water, air, and oil); results obtained to date are set forth in the Report. The impact testing machine used for impact tests on screw threads and couplings has been modified to suit the greater tensile strength of railway-carriage couplings now used. Researches now proposed concern the methods of notched bar testing and the resistance of materials to combined stress. Tests of resistance of keys and keyways to stress reversal ($\pm 20,000$ in.-lbs. torque on a $2\frac{1}{2}$ -in. shaft) indicate that a key should be an absolute fit on the sides with evidence of fit on top and bottom; each side should have a draught of 1 in 2000; shaft and hub ground to a hand-push fit and failure assumed when relative measurement of shaft and hub = 0.01 in. with $\frac{1}{8} \times \frac{1}{8}$ in. and $\frac{1}{8}$ -in. square keys: the shaft tested broke under ± 8 tons per sq. in. before half the named displacement was reached. In the aeronautics department much work has been done on the longitudinal and lateral stabilities of Bleriot models, and many aerofoils have been tested for the Royal Air-Craft Factory and private firms. The whirling table is being used to investigate pressure distribution round a propeller blade. Since Jan., 1918, 72 different kinds of stone have been tested for attrition, impact, abrasion, and cementation in the Road Board Laboratory. Various improvements have been made in the circular track and road machine; useful information has been obtained. Jakeman's machine for tracing longitudinal and cross profiles show that no waves form in a smooth uniform road if the testing machine be started very slowly. Traffic vibrations in St. Paul's and the Clock Tower were examined by two seismographs, an apparatus of the boom type measuring horizontal components and a bar instrument measuring vertical components. Kinematograph records were taken with both instruments. Oscillations of the order of 0.0001 in. were caused by 8 motor buses at 12 miles per hour. In the Clock Tower, horizontal movements were more marked. Some 80 different brake-lining materials have been tested to determine coefficients of friction under different loads, speeds, and temperatures. Tests made at rubbing speeds 600 ft., 2900 ft., and 5900 ft./min. and pressures 5 to 180 lbs. dry and up to 290 lbs./sq. in. lubricated showed for cotton-fibre, woven asbestos, teak, leather, and vulcanized fibre:—Coefficients of friction (on cast iron) 0.55-0.65; 0.8-0.85; 0.25; 0.2-0.8; 0.5. Increase with speed—nil throughout. Variation with increase of pressure—increase, nil, decrease, unknown respectively. Variation with increase of temperature—increase, increase, nil, great decrease, increase but burns soon. Cotton fibre and woven asbestos gave best and most uniform results; their extensive use is justified. In the Froude tank 75 models were tested for ship-builders; in one instance 25% power saving was effected by acting on suggestions made by the Tank Department; the lines of many vessels have been determined in connection with the tank tests. Important improvements have been made in the apparatus for testing hydroplane floats. Numerous

additions have been made to the equipment of the metallurgical departments. Tests on light aluminium alloys on test-pieces of various forms, pure and intentionally impure, are being continued on an extensive scale. An experimental rolling mill has been installed to deal with hard and soft alloys of Al, Cu, Zn, etc. An improved cascade furnace has been built for high-temperature work and kathode-ray bombardment is to be tried in silica tubes for melting-point determinations. Balloon fabrics are best protected by metallisation, say by the Schoop process. The value found for the international ohm is referred to [see Abstract No. 955 (1914)]. The London and South-Western Railway Company undertake that their electrification scheme shall not increase magnetic disturbances at the Laboratory more than 20 %. Important preliminary conclusions have been reached concerning equilibrium in the Weston cell. Tests on condenser dielectric losses cover the range of frequencies used in radiotelegraphy; castor oil has 1.088 power factor at $10^6 \sim$ and should not then be used. Over 850 wave-meter coils have been calibrated; some up to 6000 m. wave-length. The Duddell arc and tuning-forks have been used to calibrate commercial frequency meters from 800 to 800 periods. Self-inductance is of prime importance in high-frequency shunts; at certain frequencies, a solid is preferable to a stranded conductor. A means has been found to mitigate head-lamp dazzle; useful results are promised *re* constants of diffusing surfaces and media; a successful spinning apparatus is in use for high c.p. lamps. A small silicon-iron transformer proves trustworthy at a frequency of $2 \times 10^6 \sim$. Testing a.c. meters for official tests, etc., is an important and growing part of the work done. Three-phase wattmeters with transformer complete can now be tested under practical conditions. The pernicious effect of light on ebonite has been studied for the Admiralty. It is advantageous to impregnate cotton-covered coils after winding; taping may increase internal temperature 15°C . An improved type of standard resistance coil is now used. Reform is suggested in the method of specifying resistance of conductor rails; resistance of steel rails seems to vary directly, and temperature coefficient inversely, with total impurities. Research on heating of buried cables is well in hand; temperature records are to be taken on actual feeders in various districts. Emission of positive electricity from metals appears to commence at 1000° – 1400°C . For the Geodetic Survey of India, an apparatus has been built to measure electrically air temperature at various heights. Revised specifications for bayonet lamp-holders will soon be issued. Measurements have been made on a number of sparking plugs and taps. R. E. N.

1475. *Longitudinal Vibration of Wires*. G. A. Lindsay. (Phys. Rev. 8. Ser. 2. pp. 897–488, June, 1914.)—Describes experiments to determine the variations, under changing conditions, of the period and damping of longitudinal vibrations in wires of copper, steel, phosphor-bronze, and platinum-iridium. The following results were obtained:—(1) The modulus is found to be constant with small loads, but (except in the case of copper which shows a constant modulus until the elastic limit is very nearly reached) for greater loads it decreases with increasing load although the wire is still well within the elastic limit. In this latter region the frequencies for small amplitudes are found to be given by an equation of the form

$$n = (1/2\pi) \sqrt{g[a(1 + ha) + 2\beta e]/M},$$

where h is a small constant depending on the temperature changes in the wire during vibration, and e is the "elongation" (or instantaneous recovery)

of the wire for mass M . This "elongation" is the distance of the lowest point of the loaded wire from that point to which it tends to return at the instant of release owing to the elastic forces called out by the distortion. It is found that the variation of e with temperature is negligible (except for Cu in which it has to be allowed for), and that e is independent of the length of time during which the wire has been loaded. Subsidiary experiments showed that the relation between M and e may be represented by the equation $M = ae + \beta e^2$, where a and β are constants for a given wire. (2) The dynamic modulus is found to be always larger than the static modulus, this difference being explained as the result of a large after-effect, the greater part of which disappears very rapidly after the removal of load. (3) The frequency decreases with increase of amplitude for Cu and Pt-Ir. The variation is exceedingly small for phosphor-bronze, and zero in the case of steel. (4) The log. decrement is found to vary with the amplitude, this variation being, in the case of copper, very nearly proportional. The variation is not of such a character as to indicate that damping is due to internal friction.

J. W. T. W.

1476. *Stress Measurements on Board Ships.* Siemann. (Zeitschr. Vereines Deutsch. Ing. 58. pp. 1161-1169, July 18, 1914.)—The importance of determining static and dynamic stresses in ship members under all conditions is widely recognised and acted upon, but prevailing methods of calculating such stresses are of uncertain accuracy. To supplement existing knowledge, a series of stress measurements were made on ships at sea. Biles' method is said to be unsuitable for use on merchant vessels owing to the great measuring length involved. The Martens mirror extensometer apparatus requires a measuring length of 200 mm. or even less. Records of the mirror movement are obtained by a motor-driven film camera with strongly magnifying tele-objective. The whole apparatus can be erected even in confined situations; the method of using the apparatus is described and illustrated, and its errors and limitations are discussed. Numerous records taken on various parts of various vessels are reproduced and their significance is discussed. Special attention is devoted to the strength of riveted joints and to the effect of heavy seas. It appears that stresses due to wave-bending moment are much smaller than generally supposed; many failures are due to purely local stresses or to fatigue in the metal. Bow and stern must be built yet lighter to attain the ideal of a beam of uniform strength. The qualitative and quantitative results obtained lead the author to contend that important improvements in naval architecture would follow extended research along these lines.

R. E. N.

1477. *Determination of Time by Means of a Clock.* G. Beauvais. (Comptes Rendus, 159. pp. 18-20, July 6, 1914.)—The paper embodies the results of an investigation made upon a Reiffers pendulum in the Paris Observatory working at constant pressure and with electrical contact, to find the relationship between the pendulum oscillations and their registration by the mechanism of the clock. For this purpose the Abraham photographic chronograph was employed. It was found that the chronometer was only accurate to 1/100th of a second, but that the pendulum movement itself was accurate to 1/1000th of a second when an electrical mode of registration was employed. Specimen curves are given in the paper.

H. H. Ho.

1478. *Measurement of the Correction due to Pressure on the Period of a Physical Pendulum.* T. Takamine. (Mathematico-Physical Soc., Tōkyō, VOL. XVII.—A.—1914.

Proc. 7. pp. 265-268, April, 1914.)—The present note is an outcome of preliminary experiments made to test Stokes' correction to the period of oscillation of a physical pendulum due to the pressure of the surrounding gas, viz., $A\sqrt{p} + B/\sqrt{p}$, where p denotes the pressure, A and B being constants. The results obtained are also compared with those reported by the Danish Geodetic Committee in 1918. The pendulums used were of the v. Sterneck form hung in thick metal cases, the pressure correction being arrived at by changing the pressure with a pump and observing the corresponding change of the oscillation period. The pressure was measured by a mercury manometer with closed end. On plotting the observed values they were found to fall fairly well on the curve given by Stokes' formula. The actual numbers differ from the Danish, but this may be attributable to the difference in the form of the pendulum bob, etc. The so-called vacuum correction for reducing pendulum observations made at ordinary pressure was found to be but a rough approximation.

H. H. Ho.

1479. *Ratio of Periods of Two Pendulums.* P. Le Rolland. (Comptes Rendus, 159. pp. 166-169, July 18, 1914.)—Lippmann has previously given a method by which a comparison may be made of the periods of oscillation of two pendulums. The present paper describes a simple way in which the method may be carried out, and it is shown that the method possesses advantages over the method of coincidences usually employed. The principle of the method is to determine the numbers of oscillations n and n' , and the fractions of an oscillation a and a' , made by the pendulums between any two instants. The ratio of the periods is thus $(n' + a')/(n + a)$. The fractions a and a' are obtained by comparing the phases at the two instants. To determine the phase, a photograph is taken, by means of an electric spark, of an index fixed to each pendulum. At the same time, the indexes are photographed by means of a source of light whose duration is the same as the period of oscillation. Thus the displacement a at the moment when the spark takes place, and the amplitude a_0 are determined. The phase ϕ is thus given by $\sin \phi = a/a_0$. A great advantage of the method is that its application can be rendered entirely automatic. A clockwork mechanism controlling the electric sparks can be adjusted so that the interval between the sparks corresponds exactly to some definite number of oscillations of one of the pendulums. Discussion of the sources of error shows that it is necessary to have the planes of oscillation and the photographic plate accurately parallel. This can be secured in a simple manner, but it is possible to eliminate all error. With this method the periods of, e.g., two seconds-pendulums can be compared in a few minutes with an error of at any rate not more than 1 in a million, whereas the method of coincidences would require several hours. This shortened period of observation has distinct advantages, for it eliminates disturbing effects and allows the variations with time of the period of oscillation to be followed. The author has been able to show in this way that all the knife-edge pendulums he has studied show a systematic diminution of the period as the oscillations are damped, the variation being due to the cylindrical form of the knife-edges.

A. W.

1480. *Atomic Structure.* A. van den Broek. (Nature, 98. pp. 241-242, May 7, 1914.)—In reply to Nicholson [Abstract No. 477 (1914), and Ibid. p. 680, Feb. 5], van den Broek cites and discusses in detail varied experimental evidence in support both of Bohr's theory of atomic constitution generally, and of his own hypothesis, accepted by Bohr as one of his fundamental

assumptions, that the nuclear charge of a Rutherford atom is equal to the atomic number. **J. W. Nicholson.** (*Ibid.* pp. 268-269, May 14, 1914).—In reply to van den Broek, Nicholson observes that his contention was that van den Broek's hypothesis is fundamentally correct in principle, but inconsistent with Bohr's theory in its present form. Soddy and Fajans' recent generalisation of this periodic table [Abstract No. 170 (1914)], against which mathematical considerations cannot be raised, tends to support van den Broek, but does not show identity between the nucleus charge and the tabular place; the latter might differ constantly from the former by, say, 1 or 2. If completely correct, then Bohr's theory cannot be modified to account for Röntgen-ray spectra. Moreover astrophysical spectra and Bourget, Buisson and Fabry's application of their interference method to a nebula line [Abstract No. 140 (1914)], show that very simple elements can exist in which the atomic number differs from the number of electrons, so that van den Broek's hypothesis cannot be a complete principle, although perhaps satisfactory for the stable terrestrial elements. Bohr's theory is not the only possible explanation of Moseley's results. The author will shortly publish a simpler one, obtained by more ordinary dynamics, which, by attaching a definite structure to the nucleus, accounts for other phenomena such as the velocity of emitted α -particles. It differs only in detail from van den Broek's hypothesis. Mathematically, the only possibility of coplanar rings is the case in which bound electrons *do not repel* each other, a supposition in complete contrast with the present form of Bohr's theory. Many physicists have not yet realised that the wave-length from a ring depends fundamentally, not on the radius alone, but on the angular velocity, the frequency being of the order c/w , where c is the velocity of light, and w the frequency of vibration of the ring about its steady rotation. A ring of *any* radius can give any wave-length, with proper angular velocity. So also can any portion of a structural nucleus, and the Röntgen rays may come from the nucleus. Bohr's mathematics show that in his theory also the wave-lengths are determined by the order of c/w , and not in any fundamental sense by the radius. G. W. DE T.

1481. *Einstein's Gravitational Field and the Electromagnetic Field of Maxwell-Lorentz.* **T. De Donder** and **O. De Ketelaere.** (*Comptes Rendus*, 159. pp. 28-27, July 6, 1914.)—Mathematical. E. H. B.

1482. *Relativity Principle and Intra-atomic Energy.* **G. Le Bon.** (*Comptes Rendus*, 159. pp. 26-27, July 6, 1914.)—A comparison of Einstein's theory and the author's views as set forth in his *L'Evolution de la matière*. E. H. B.

1483. *Relativity Principle.* **R. Hiecke.** (*Deutsch. Phys. Gesell., Verh.* 16. 12. pp. 569-576, June 80, 1914.)—Discusses the difficulties in the way of the acceptance of this principle by physicists. [See Abstract No. 947 (1906).] E. H. B.

1484. *Relativity Principle and Accelerated Motion.* **F. Kottler.** (*Ann. d. Physik*, 44. No. 5. pp. 701-748, June 19, 1914.)—A highly analytical treatise illustrated with folding tables descriptive of the various motions dealt with. E. H. B.

1485. *Dynamics of Elastically coupled Point-systems.* **E. Schrödinger.** (*Ann. d. Physik*, 44. No. 6. pp. 916-984, July 8, 1914.)—Mathematical. VOL. XVII.—A.—1914.

1486. *Theory of Long Waves and Bores.* Rayleigh. (Roy. Soc., Proc. Ser. A. 90. pp. 824-828, July 1, 1914.)—In the theory of long waves in two dimensions, supposed to be reduced to a steady motion, it is assumed that the length is so great in proportion to the depth of the water that the velocity in a vertical direction can be neglected, and that the horizontal velocity is uniform across each section of the canal. It is found that unless h^2 can be neglected, where h is the elevation of the water at any point of the wave, it is impossible to satisfy the condition of a free surface for a stationary long wave—*i.e.* it is impossible for a long wave of finite height to be propagated in still water without change of type. Since a constant gravity is not adequate to compensate the changes of pressure due to acceleration and retardation in a long wave of finite height, an investigation is made to find what law of force will allow long waves of unlimited height to travel with type unchanged. This is found to be a force varying inversely as the cube of the distance from the bottom of the canal. The generalised form of the relation between velocity and height which must be satisfied in a progressive wave, whether the type be permanent or not, is then given. An application is next made to bores where the uniform levels on the two sides of the variable region are different. Finally, experiments on the formation of bores are described. H. H. Ho.

1487. *On a Typical Form of Isobars.* T. Terada. (Mathematico-Physical Soc., Tokyo, Proc. 7. pp. 258-264, April, 1914.)—The form of isobars referred to is a pronounced discontinuity in the direction of the curves of equal barometric pressure as they pass from the Asiatic continent to the ocean in the neighbourhood of Japan. The observed pressures over the ocean are lower than what might have been expected in comparison with the observed values over the neighbouring continent. The author suggests that the phenomenon may be explained by the fact that the frictional effects of the surface of the ocean are not so great as the corresponding effects over the land. Consequently wind velocities over the ocean corresponding with a definite barometric gradient are greater than wind velocities over the land for the same gradient. An application of the equation of continuity to the air over an area extending from sea to land shows that a pressure distribution like that observed may be thereby produced. R. C.

1488. *The International Kite and Balloon Ascents.* E. Gold. (Meteorolog. Office Geophysical Mem. No. 5. pp. 65-144, 1913.)—This is a dissertation which obtained the first prize awarded in 1912 by the German Meteorological Society. It is based mainly on the results of soundings of the upper air from Jan., 1904, to Nov., 1909, derived from ascents mostly in Europe of kites, manned balloons, registering balloons, and pilot balloons. The paper is divided into two parts dealing respectively with temperature and wind. Under the former head are treated (1) the average temperature conditions from the surface to 15 or 16 km., (2) the annual variation of temperature at different heights, (3) the diurnal variation of temperature, (4) the stratosphere, (5) temperatures under cyclonic and anticyclonic conditions. The discussion of wind is divided into (1) the connection between the direction of flight of balloons with that of the gradient wind, (2) results for the variation of wind direction and velocity with altitude. The conclusions reached are very numerous, and the work is a standard of reference for students of modern meteorology. It contains many tables of normal values for the upper air. R. C.

1489. *Pressure in Absolute Units.* W. N. Shaw. (Monthly Weather Rev. 42. pp. 5-7, Jan., 1914.)—The author discusses the replies to be given to the following three questions: (1) What units of pressure (and temperature) should be adopted in the publication of monthly values of pressure for a *réseau mondial*? (2) What units should be adopted by teachers who wish to interest students of physics in meteorology? and (3) What graduation should be employed for a barometer in order to commend most effectively to the wider public the results of meteorological study? The author finds the answer to all these questions in absolute units on the C.G.S. system. The fact that mean pressure at station level is closely equal to 100 cb. (centibars) in absolute units (so that readings on this scale give pressures as percentages of the mean value) is given weight in supplying the answer to question (3). Attention is drawn to the fact that mm. of mercury form as illogical a measure of pressure as inches, and it is argued that both should be resigned in favour of absolute pressure units. J. S. Di.

1490. *Classification of the Methods of Transition from Rain to Blue Sky.* W. I. Milham. (Monthly Weather Rev. 42. pp. 94-97, Feb., 1914.)—During the passage of a low-pressure system to the north of a station certain general weather changes take place. These changes, though having a general similarity, are not all exactly of the same type and the paper suggests certain different classes into which they seem to fall. J. S. Di.

1491. *Meteorological Aspect of the Smoke Problem.* H. H. Kimball. (Monthly Weather Rev. 42. pp. 29-35, Jan., 1914. Condensed, with additions and revision, from Smoke Investigation Bull. No. 5. Mellon Inst. of Industrial Research, Univ. of Pittsburgh, 1913.)—There is first given a general account of fogs, with their effects upon the limits of visibility, the quantities of soot contained in the atmosphere, etc. The meteorological properties are then discussed. It is pointed out that wet fogs form more readily and are dispersed less easily by sunshine in the smoky air over a city than in the clearer air of the country. Not only do town fogs reduce the number of hours of sunshine received, but the percentage diminution in the intensity of what daylight is received is even greater than the diminution of hours of sunshine. Much evidence is brought forward to show that night minimum temperatures are considerably raised by the presence of a foggy layer, while the day maxima are but slightly affected. Taking six American towns it is found that the minimum temperature averages about 8.6° F. higher, and the range of temperature 4° less, than the corresponding data for surrounding stations. J. S. Di.

1492. *Atmospheric Transparency for Radiation.* F. E. Fowle. (Monthly Weather Rev. 42. pp. 2-4, Jan., 1914.)—A table is reproduced from an earlier publication showing the transmissibility of radiation through dry air above Mount Wilson (7780 m.) for different wave-lengths [see Abstracts Nos. 1981 (1913), 482 (1914).] Corresponding figures derived by Rayleigh's theory from the number of molecules in the air are also given. The agreement between the two sets of figures is remarkable. This shows that molecular scattering fully accounts for the loss of radiation in transmission through dry air, but in the case of moist air the same theory does not so fully account for the loss. It is suggested that the formation of ions or nuclei plays some part in the loss in this case. At stations below 1000 m. height there is a third cause of loss in atmospheric dust. If the transmitted radiation be calculated by

means of the factors for dry and moist air here put forward, values in good agreement with those obtained by direct measurement will be obtained for stations above this 1000-m. dust-layer. J. S. DI.

1493. *The Gulf Stream*. M. W. C. Hepworth. (Nature, 98. pp. 441-448, June 25, 1914. Paper read before the Roy. Geographical Soc., May 21, 1914.)—That wind is the prime cause of all ocean currents is demonstrated by comparison of a map of mean wind with a corresponding chart of currents. By temperature and salinity observations the course of the Gulf Stream can be traced out across the Atlantic eastwards. The effect of the temperature of this stream upon the temperature of the British Islands is traced through the two years 1911 and 1912. When the stream is abnormally active on the American coast its resistance to the Labrador current is carried farther north than usual with the result that its north-easterly branch pursues its course into higher latitudes, while with a weak Gulf Stream the converse occurs. J. S. DI.

1494. *The Floods of 1918 in Ohio and Lower Mississippi Valley*. A. J. Henry. (Weather Bureau, Bull. Z [117 pp.], Washington, 1918.—A profusely illustrated report on the disastrous floods of March and April, 1918, dealing at length with the meteorological conditions just previous to the catastrophe. L. H. W.

1495. *Experimental Determination of the Earth's Elastic Properties*. H. G. Gale. (Science, 89. pp. 927-938, June 26, 1914.)—This paper is a discussion of recent investigations made of the earth's elastic properties. If the earth were a perfectly fluid mass there would be no change of the plumb-line relative to the earth's surface, and the so-called "deflection of the vertical" could not be detected, while if the earth were perfectly rigid the plumb-line would move back and forth, as the positions of the sun and moon vary, by an amount which can be calculated with an accuracy limited only by knowledge of the masses and relative positions of the sun, earth, and moon. Since the earth is partially rigid the excursions of the plumb-line are a certain fractional part of the full computed value, and, after this fraction has been found by experiment, it is possible to compute the rigidity of the earth. The earlier work of Darwin, Paschwitz, Ehlert, v. Rebeur, Kortazzi, Hecker, and Orloff is briefly summarised in the paper. Chamberlain and Moulton, being desirous of securing definite data on the plasticity of the earth on account of its vital bearing on planetary evolution, interested Michelson in the problem, and he carried out a series of measurements using a long horizontal water surface in place of a long pendulum and measuring the changes of level at its ends. Details of this work are very fully described. The earth was found to yield more readily to distorting forces in the N.-S. direction than in the E.-W., a result foreshadowed by Schweydar. It was also found that the maxima and minima of the observed and computed tides occurred almost exactly simultaneously. The mean rigidity of the earth was found to be about 8.6×10^{11} , and the viscosity 10.9×10^{16} C.G.S. units, being of the order of magnitude for steel. H. H. Ho.

1496. *Further Evidence for the New Physical Theory of the Formation of the Primitive Oceans and Continents*. E. Belot. (Comptes Rendus, 159. pp. 89-92, July 6, 1914.)—In a preceding note [see Abstract No. 823 (1914)] the author has shown how the translatory movement of the earth through the primeval nebula produced in the primitive atmosphere a circulation which chilled the VOL. XVII.—A.—1914.

Antarctic and caused there the first aqueous precipitation. Two further causes combined in this cooling effect—namely, the altitude of 8000 m. and the gaseous expansion produced above it, the latter being similar to the cooling effect in the rear of projectiles. The author applies his theory to the alkaline chlorides, iodides, and fluorides, which are volatile between 700° and 800°, and which would exist in the primitive atmosphere as found at present in volcanic emanations. These salts will be precipitated before water, and in consequence the latter will be almost saturated from the commencement. If, on the other hand, Joly's hypothesis be true, that the sea was originally fresh and had acquired its salt by continental lixiviation, then vegetation could not have appeared at the commencement of the primary epoch, owing to the excess of salt in the soil. Several dynamical consequences are drawn from this theory. The Antarctic erosion, as shown by the Weddell and Ross Seas, furnished material for transport by ocean currents and gave rise to barriers, now outlined by continental points, islands, etc., between latitudes 40° and 50° S. in the Atlantic and Indian Oceans, forcing the water to the Pacific which is consequently the most antique ocean. This unsymmetrical water distribution, which in gaseous form was uniform throughout the whole atmosphere, was compensated by a corresponding surface movement so that the continents have oceans for their antipodes. Not only the latter, but also the quantitative relationship is true, viz. that the weight of the oceans equals that of the land above the base level —2520^m, and, therefore, in order to build continents above the primitive surface of the earth, the oceans have eroded a weight of material equal to their own. Finally, owing to erosion the more resistant materials remain beneath the primitive oceans, which would explain the greater intensity of gravity and magnetism at sea than upon land.

H. H. Ho.

1497. *Motions of the Brighter Stars of Class A in Relation to the Milky Way.* **H. C. Plummer.** (Lick Observatory, Bull. No. 212.)

1498. *Radial Velocities of 915 Stars.* (Lick Observatory, Bull. No. 229.)—Gives the results obtained at Mount Hamilton and Santiago for the brighter stars of classes F, G, K, and M whose radial velocities appear to be substantially constant.

L. H. W.

1499. *Real Motions of 100 Stars of Large Proper Motion, whose Radial Velocities have been determined.* **H. C. Wilson.** (Lick Observatory, Bull. No. 214.)

1500. *Preliminary Radial Velocities of 212 Brighter Class A Stars.* **W. W. Campbell.** (Lick Observatory, Bull. No. 211. Paper read before the National Academy of Sciences, Washington.)

LIGHT.

1501. *Type-reading Optophone*. **E. E. Fournier d'Albe**. (Roy. Soc., Proc. Ser. A. 90. pp. 878-875, July 1, 1914.)—A modification of the author's "optophone" [Abstracts Nos. 964 (1918) and 887 (1914)], an instrument designed to substitute the sense of hearing for that of sight. In the previous instruments transparent letters 5 cm. high could be read, but by the modifications here described it should be possible, with practice, to read ordinary type. These consist in decreasing the length of the line of intermittent luminous dots which illuminate the letter to the size of ordinary type, using the light to actuate the selenium or antimonite bridge after diffused reflection by the printed surface, and in increasing the sensitiveness of the telephone receiver connected to the bridge, by means of a Brown telephone relay.

T. H.

1502. *Phase Change by Reflection—Primarily in the Ultra-violet*. **O. H. Gish**. (Phys. Rev. 8. Ser. 2. pp. 858-868, May, 1914.)—Following a method essentially that used by Wernicke, thin parallel plates of mica were used in part of the work here described, but certain advantages led finally to the use of thin wedge-shaped plates of glass, the method adopted in the latter case being that used by Drude and by Koenigsberger and Bender [Abstract No. 1605 (1908)]. The substances investigated for phase change were silver, fuchsin, Doppel-grün, crystal-violet, cyanin, eosin, and aniline-orange. In the observations with mica a thin mica plate coated, except for a central strip, with the substance to be tested, was so mounted that a source of light was focused by means of a quartz lens upon the mica at an angle of incidence of about 2.5° . Then, by means of another quartz lens an image of this plate by the reflected light was cast on the slit of a 4-ft. Rowland grating spectroscope. With a Nernst glower and exposures of 8 hours' duration it was found that the limit into the ultra-violet to which observations could be extended was $840\text{ }\mu\mu$. Using thin glass wedges selected from glass cover-slips a discontinuous spectrum could be employed. For this a copper arc was used, and the glass plate, diaphragmed down to an aperture of 4 by 10 mm., mounted in place of the spectroscope slit. By means of two quartz lenses and a total-reflection quartz prism an image of the arc was formed on the plate, the light being incident as before at an angle of about 2.5° . When properly adjusted all the images of the set of bands obtained were found well defined. Photographic records were obtained upon films of such length as to include the first order spectrum and a large portion of the ultra-violet region in the second order. The displacement of the bands, which serves as a measure of the phase-change relative to glass, was measured with a micrometer microscope. The photographs taken for silver on mica showed a relative shift of about three-tenths of a band at $580\text{ }\mu\mu$, decreasing slowly with decreasing wave-length to about $442\text{ }\mu\mu$, where the two sets of bands seem to coincide. The shift with silver on glass was practically the same as for mica, except that the position at which the bands coincide seemed to be shifted farther toward the ultra-violet (to about $890\text{ }\mu\mu$). They continued to coincide throughout the transmission region for silver and as far as the photograph showed distinct bands ($296\text{ }\mu\mu$). The measurements on fuchsin show a decreasing phase-

change for decreasing wave-length until between 420 and 440 $\mu\mu$, where coincidence, or at least a minimum phase-change, is observed. Beyond this point the phase-change suddenly mounts to its highest value, after which a gradual decrease is observed to 280 $\mu\mu$, where its value is 0.27 wave-length. It was found that between 440 and 820 $\mu\mu$ fuchsin was practically as transparent as glass. The abrupt change in phase difference at 420 $\mu\mu$ from zero to half a wave-length probably arises from the fact that the refractive index of fuchsin, which is less than that of glass at 425 $\mu\mu$, rises above it between 425 and 410 $\mu\mu$. The value of the phase-change at the surface of Doppel-grün goes through two minima between 600 $\mu\mu$ and 280 $\mu\mu$, one minimum being at about 520 $\mu\mu$, the other at about 390 $\mu\mu$. Transmission maxima were found between 496 and 487 $\mu\mu$ and between 889 and 840 $\mu\mu$. Results similar in general character were obtained with the other substances dealt with, and all results are tabulated and graphed.

A. W.

1503. Measurement of Refractive Index of a Drop of Liquid. F. E. Wright. (Washington Acad. Sci., Journ. 4, pp. 269-279, June 4, 1914.)—The refractive index is the most important optical constant with which a petrographer has to do, since its determination on a single mineral grain enables him practically to identify the mineral within narrow limits. The determination of the refractive indices of irregular mineral grains measuring 0.01 mm. in diam. is best accomplished by means of the immersion method, in which the refractive indices of the mineral grain are compared with that of the liquid in which it is immersed. In the present paper the measurement of the refractive index of a single drop of liquid is considered in some detail. The accuracy of the standard methods (with the exception of the Abbe refractometer methods) for this purpose is discussed, and certain new modifications are suggested which render possible the application of such methods to a single drop of liquid. The use of a diffusing screen in front of monochromatic light sources is emphasised. A new type of hollow prism is suggested which has proved satisfactory and convenient, and with which measurements (accurate to the fourth decimal place) can be made either by a method of auto-collimation or by the minimum deviation method or by Gifford's method. The prism consists of two optically plane, parallel glass plates ($10 \times 20 \times 2$ mm.) held in place against a 90° glass prism (10×10 mm.) by means of a brass clamp. The liquid is introduced between the glass plates and is held in place by capillarity. A semicircular notch in the middle of the edge of the glass plates prevents the liquid from creeping up along the ridge formed by the glass plates, and thence into the prism support. The use of a cover of specially prepared tin-foil on a drop of liquid to be measured on the Abbe-Pulfrich crystal total-refractometer is suggested as a satisfactory method for obtaining the phenomena of grazing incidence even on a thin film of liquid. Five new methods are also described for measuring the refractive index of a drop of liquid with the petrographic microscope. Of these methods, method 5, which requires solely a plane-parallel glass plate of high refractive index, with one edge bevelled at an angle of 60° , is the simplest and most convenient. With it the refractive index of the liquid can be easily measured to the third decimal place, an accuracy which is sufficient for all determinative purposes. The other methods are interesting and of about the same order of accuracy, but they are less simple and therefore less useful. The methods of Clerici, Viola, Pilschikow, Smith and Clay are presented briefly, but they are also without exception less simple and less accurate than method 5, which is accordingly recommended, especially as the cost of the glass plate required

is slight, and the amount of liquid necessary for measurement is a very small drop.

It is of the greatest importance to the science of petrology that the materials, of which it treats, be studied in a quantitative way; the refractive indices of the rock-making minerals, many of which are isomorphous mixtures, are fundamental optical constants which should be measured and included in every detailed description of a rock. A. W.

1504. *Autostereoscopic Photography*. E. Estanave. (Comptes Rendus, 159. pp. 164-166, July 18, 1914.)—The author has previously shown [Abstract No. 438 (1909)] that the autostereoscopic plate, which has opaque lines ruled on the surface of the glass which does not carry the sensitive film, allows photographs to be obtained giving to direct vision the sensation of stereoscopic relief. The present paper deals with a similar effect when only a single image of the object dealt with is available. A. W.

1505. *Theory of Lippmann Colour Photography*. K. Försterling. (Phys. Zeitschr. 15. pp. 225-234, March 1, 1914.)—A mathematical study of the theory of Lippmann photography on the basis of the variation of the dielectric constant in the various layers of the emulsion. It is shown that a perfect rendering of mixed colours is theoretically impossible. Most natural colours consist of broad bands in the spectrum. Of these bands the maxima are rendered chiefly. Thus the colours are more brilliant than true to the original. E. E. F.

1506. *Circulation of the Ether in Rotating Interferometer*. G. Sagnac. (Journ. de Physique, 4. Ser. 5. pp. 177-195, March, 1914.)—A paper dealing more fully with the author's rotating interferometer described previously [Abstract No. 216 (1914)]. Interference fringes are obtained with two luminous beams propagated in opposite directions round a closed circuit surrounding an appreciable area. When the whole apparatus is rotated, first in one direction and then in the other, photographs of the fringes taken on the same plate exhibit a relative displacement proportional to the width of the fringes and representing a definite phase-difference characteristic of the effect of the motion of the circuit as a whole. This phase difference is quite distinct from any effect due to the accidental or elastic movements of the optical arrangements, and is due to the movement of the circuit as a whole with respect to the ether of space. The effect is just as if an ether wind blew in the immobile circuit in the opposite sense to the direction of propagation and diminished the velocity of the light-waves. Theory is given showing how the effect depends on the area of the circuit, the velocity of rotation, etc., and the experimental measurements are in agreement with results calculated on the supposition that the ether is an immobile fluid transmitting luminous waves with an invariable velocity. Thus this rotating optical effect can be regarded as an effect, of the first order, of motion with respect to the ether, and confirms its existence. A. W.

1507. *Electromagnetic Emission Theory of Light*. J. Kunz. (Phys. Rev. 8. Ser. 2. pp. 464-475, June, 1914.)—This is an endeavour to found a new theory of the physical universe which shall avoid some of the difficulties and drawbacks of the theory of relativity. This alternative theory agrees with that of relativity in many features, but gives an entirely different aspect of the world. This electromagnetic emission theory of light is a compromise between the emission theory and the wave theory. Each electric charge is supposed to be surrounded by an electromagnetic field residing in the
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medium, which field itself forms the mass of the charge. Thus instead of having a continuous medium, ether, we have as many media as there are electric charges. Each individual electromagnetic field extends throughout the universe, but is essentially concentrated in the immediate neighbourhood of the electron. The theory is worked out mathematically and applied to the change of mass with velocity, etc.

E. H. B.

1508. *Path of Light in Rotating Solid.* E. M. Anderson. (Roy. Soc., Edinburgh, Proc. 84. pp. 69-76, 1918-1914.)—A mathematical calculation of the path of a light ray in a rotating homogeneous and isotropic solid, the analysis being based on the Fresnel formula that the ether being fixed, the medium imparts $(\mu^2 - 1)/\mu^2$ of the amount of its own motion to the advancing disturbance; this conclusion being also a necessary consequence of the modern theory of relativity. Within the limits considered the curve is part of a circular helix.

E. H. B.

1509. *Infra-red Dispersion of Diatomic Crystals.* W. Dehlinger. (Phys. Zeitschr. 15. pp. 276-283, March 15, 1914.)—Nernst's combination of Einstein's and Debye's formulæ involves two frequencies characteristic of diatomic crystals. These frequencies may be expected to be proportional to the square roots of the masses of the two constituent atoms. The author does not agree with the five rest-ray frequencies introduced by Born and v. Kármán, but believes there is only a single rest-ray frequency. He calculates the dispersion of a diatomic crystal built on Madelung's model, and arrives at a formula identical with that of Ketteler and Lorentz, which is based on simply oscillating, independent charges.

E. E. F.

1510. *Radiation of a Point Source close to the Surface separating two Media.* L. Mandelstam. (Phys. Zeitschr. 15. pp. 220-225, March 1, 1914.)—If the source of light is immersed in a rare medium, but very close to its surface of separation from a denser medium, the light in the latter is no longer confined to a cone, but spreads in all directions. Conversely, if a convergent beam of light falls through glass into a fluorescent liquid, there is a fluorescent spot if the focus is close to the liquid, even though the angle of incidence is greater than the critical angle. The absorbing layer does not, however, exceed in thickness the wave-length of the incident light. The author investigates the electromagnetic theory of this effect, and arrives at a formula which supplements that of Sommerfeld.

E. E. F.

1511. *Appearance of the Eye when subjected to an Intense Beam of Ultra-violet Rays.* G. Michaud and J. F. Tristan. (Archives des Sciences, 87. pp. 845-846, April, 1914.)—Bugnion, in the course of a study of the eyes of nocturnal insects, has advanced the following hypothesis: Perhaps it may be supposed that certain obscure rays, by the effect of chemical action, are transformed into visible rays when they are reflected at the base of the eye. The eyes of nocturnal animals give under certain circumstances a very beautiful luminosity, so that by comparison the lamp which illuminates them only appears to glow feebly. The authors have observed an effect which, if it does not positively confirm this hypothesis, seems nevertheless to be in its favour. If the eye of a cat is examined in daylight, it is seen that the pupil always stands out black on the clear and generally greenish ground of the iris; variations of intensity of the illumination affect only the dimensions and shape of the pupil. If, however, the observation is repeated in a completely

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dark room, allowing to fall on the eye of the cat a beam of sunlight passed through a Zeiss uviol filter, the pupil is seen to stand out in luminous green on the purplish black ground of the iris. The same results have been obtained with the eye of a dog and with a human eye. In each case the light emitted by the pupil was of a decided green colour, that from the human eye apparently being the most intense of the three. This curious appearance of the eye observed in ultra-violet light is probably caused, first, by the fluorescence of one of the media inside the eye, perhaps the purple of the retina, and secondly by a very strong absorption of the ultra-violet light by the iris, the pigment of which plays, in this case, the same protective part as the pigment of the skin. The authors have previously shown that when photographed with ultra-violet light of wave-length $\lambda 8160$ to $\lambda 8260$, the skin of a white man appears just as black as that of a negro or an Indian. A. W.

1512. Fresnel's Reflection Formulæ. A. Wiegrefe. (Ann. d. Physik, 44. No. 2. pp. 288-289, May 12, 1914.)—Mathematical paper dealing with the reflection and refraction formulæ for complex angles of incidence and refraction.

E. H. B.

1513. Ponderomotive Effects of Circularly Polarised Light. K. Schaposchnikow. (Phys. Zeitschr. 15. pp. 454-455, May 1, 1914.) **H. Busch.** (Phys. Zeitschr. 15. pp. 455-457, and pp. 457-458, May 1, 1914.)—Mathematical discussions of this subject. [See Abstracts Nos. 1672 (1910) and 849 (1914).]

E. H. B.

1514. Concave Diffraction Gratings. G. Guglielmo. (Accad. Lincei, Atti, 23. pp. 282-287, Feb. 25, 1914.)—Describes several new methods of mounting and working concave gratings.

E. E. F.

1515. Pressure of Light on a Perfectly Conducting Semi-plane. P. S. Epstein. (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 449-456, May 30, 1914.)—A mathematical treatment obtaining expressions for the pressure, the vibrations being taken successively parallel and perpendicular to the edge.

E. H. B.

1516. Symmetry of Electromagnetic Tensors. M. Abraham. (Ann. d. Physik, 44. No. 4. pp. 537-544, June 4, 1914.)—With reference to a recent paper by K. Schaposchnikow [see Abstract No. 849 (1914)], as to the ponderomotive couple existing at a source of light, the present author discusses mathematically the question as to the symmetry of the electromagnetic world-tensors concerned.

E. H. B.

1517. Lecture Experiment on the Irrationality of Dispersion. S. P. Thompson. (Phys. Soc., Proc. 26. p. 154, April, 1914.)

1518. Theory of the Grating. W. v. Ignatowsky. (Ann. d. Physik. 44. No. 8. pp. 369-386, May 26, 1914.)—Mathematical.

1519. The Dispersion of a Light Pulse by a Prism. R. A. Houstoun. (Roy. Soc., Proc. Ser. A. 90. pp. 298-312, May 28, 1914.)

1520. Types of Abnormal Colour Vision. L. Bell. (Amer. Acad., Proc. 50. pp. 8-18, May, 1914.)

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1521. *Theory of Rotational Optical Activity in Isotropic Media.* G. H. Livens. (Phil. Mag. 27. pp. 994-1009, June, 1914.)—In some recently published papers [Abstracts Nos. 1815 (1918) and 1058 (1914)] the author, starting from a suggestion originally made by Lorentz, has given indications towards a new form of the electron theory of the optical rotatory power in isotropic media. The results obtained are in such close agreement with the experimental facts that there can be little doubt as to the correctness of the fundamental assumptions on which they are based. The object of the present paper is to give as complete a statement of the theory as possible, in the hope that it may lead to further experimental investigations of its appropriateness. The general formulæ obtained, although rather complicated, are nevertheless sufficiently general to contain an effective explanation of all the apparent anomalies in the behaviour of the intrinsic optical rotatory power of isotropic media. This theory, which makes the rotative power depend essentially on the ordinary dispersion and absorption in the medium, would indicate large variations of this rotative power consequent on any variation of condition which alters to any appreciable extent the usual dispersive and absorptive properties of the medium. **G. Bruhat** (Ibid. 28. pp. 802-804, Aug., 1914).

A. W.

1522. *Speed of Series Electrons.* J. Stark. (Phys. Zeitschr. 15. pp. 265-267, March 15, 1914.)—The Zeeman-effect, in connection with the "Stark-effect" (of an electric field on the spectrum lines) enables us to assign an upper limit to the intra-atomic velocity of the electrons emitting series spectra. Considerations of the sharpness of the components and the atomic thermal agitation lead to 2×10^9 cm./sec. as a superior limit. This gives an amplitude below 10^{-10} cm. for a wave-length of 600 μ .

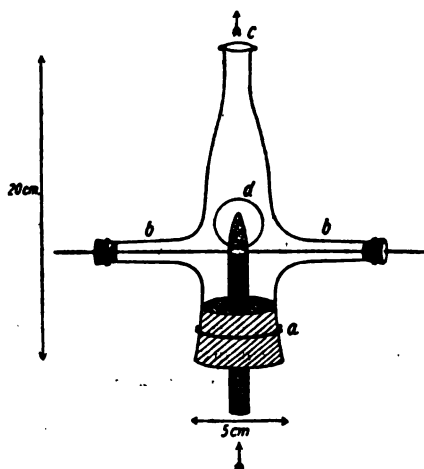
E. E. F.

1523. *Resonance Radiation of Mercury Vapour.* A. v. Malinowski. (Ann. d. Physik, 44. No. 6. pp. 985-968, July 8, 1914.)—A brief account of the results of the research here described has already been given [see Abstract No. 222 (1914)]. The present paper is more particularly concerned with the breadth of the line $\lambda 2586\cdot 7$, or rather of its components, as well as the variation of the absorption coefficient for layers of vapour of different thicknesses. Particulars are also given of the variation of absorption in a magnetic field for different air-pressures. The results of the observations on the absorption of resonance radiation by layers of mercury-vapour of different thicknesses can be represented sufficiently well by the formula obtained on the supposition of an exponential intensity distribution in emission and absorption lines (after Rayleigh). The investigations in a magnetic field show that the resonance lines $\lambda 2586\cdot 7$, as well as the absorption lines of the same wave-length consist of several sharp and well-defined components. Calculation based on Rayleigh's formula gives for the breadth of the components a value which differs very little from the theoretical (about $2\cdot 8 \times 10^{-4}$ Å. unit). An approximate calculation of the damping coefficient leads to a very small value ($1\cdot 2 \times 10^{-10}$), which is only four times as great as Planck's value. The molecules participating in the resonance probably make up only a small fraction of the total number. With increased air pressure in the absorption chamber from about 0.008 mm. up to atmospheric pressure, the components of the absorption lines broaden more and more, until finally they merge into a single line. In a very high vacuum, obtained by the use of liquid air, the components are sharper and better isolated from one another. The structure of the lines appears to be uninfluenced by the variations of the pressure.

A. W.

1524. *Arc and Spark Spectra of Copper in International Units.* **K. Hasbach.** (Zeitschr. wiss. Phot. 18. pp. 899-480, May, 1914.)—Describes wave-length measurements of the arc and spark spectra of copper, the 6.34-m. radius Rowland concave grating of Bonn University being used. Tables are given of the results, together with those of Kayser and Runge and of Exner and Haschek for comparison. Tables are also given of lines in the first and second subordinate series and in the principal series. **A. W.**

1525. *Use of Uncondensed Spark for Production of "Flame Spectra."* **A. Harnack.** (Phys. Zeitschr. 15. pp. 578-581, June 1, 1914.)—A new method is described in which the uncondensed spark between Pt electrodes may be utilised to obtain a "spark-flame," which will yield flame spectra of substances introduced into it. The apparatus is shown in the accompanying diagram. The Pt electrodes pass through the side-tubes *b, b*, and just reach the top of a porcelain tube passing through the cork at the bottom. When the electrodes are connected to an induction coil provided with a mercury break (frequency 50 to 60) and a strong blast of air is sent through the porcelain tube, a so-called spark-flame is obtained at the top of the tube. If the air blast is charged with a metallic salt solution the spark-flame becomes coloured as in



the case of a Bunsen flame, or the metallic salt may be introduced in powder form, giving a greater concentration. The flame thus obtained gives an intense source of light, exposures of from 2 to 10 mins. yielding very satisfactory spectrograms. An observation window *d* of quartz allows the ultra-violet region to be dealt with. The spark-flame yields a typical flame spectrum, and is very similar to the oxy-hydrogen blow-pipe flame. The spark-flame can be operated with different gases. With hydrogen a flame is obtained similar to the chlorine-hydrogen flame; both are oxygen-free flames, but the electrical conditions of the one give rise to essentially different phenomena. A comparison was made of the spectra of the alkaline earths given by the spark-flame operated with oxygen and with hydrogen, with those of the oxy-hydrogen flame and the chlorine-hydrogen flame. Photographs are reproduced, and the results discussed. Further research on these lines is in progress. **A. W.**

1526. Optical Resonance of Sodium Vapour under Excitation of a Single D-line. R. W. Wood and L. Dunoyer. (Comptes Rendus, 158. pp. 1490-1492, May 25, 1914.)—The experiments described were undertaken with a view to ascertaining whether it was possible to obtain luminous sodium vapour emitting only one of the two D-lines. The phenomenon of surface resonance was utilised, and either D_1 or D_2 light was allowed to fall on the bulb containing the Na-vapour, the method of separating the two rays being that previously described by Wood [Abstract No. 1068 (1914)]. Using the more intense D_2 light, it was found that the surface resonance light only emitted the ray D_2 and not D_1 at all. It appears extremely probable that the resonance excited by D_1 should not contain D_2 . This is more difficult to verify an account of the smaller intensity of the ray, and the necessity of maintaining constant, during all the time of exposure, the temperature of the quartz block employed; it is also necessary to avoid too great a blackening of the bulb. Some interesting results were also obtained of the way in which the relative intensity of the resonance rays varies when the quantity of sodium in the flame is altered. [See also Abstracts Nos. 299 (1906) and 859 (1914).] A. W.

1527. Separate Excitation of the Centres of Emission of the D-lines of Sodium. R. W. Wood and L. Dunoyer. (Phil. Mag. 27. pp. 1018-1025, June, 1914.)—Deals with the same experiments as the paper dealt with in the preceding Abstract, but gives greater detail. Photographs are reproduced. [See also Abstracts Nos. 299 (1906), 1289, 1240, and 1250 (1914).] A. W.

1528. The So-called Cyanogen Bands. W. Grotrian and C. Runge. (Phys. Zeitschr. 15. pp. 545-548, June 1, 1914.)—Experiments are described which show that the so-called cyanogen bands at $\lambda 8860$, $\lambda 8590$, $\lambda 8868$, $\lambda 4216$, and $\lambda 4606$ are strongly generated in a long nitrogen arc light, when neither cyanogen nor carbon is present. These bands are therefore to be attributed to nitrogen. This conclusion was reached as the result of a number of different experiments, and it is shown that it is not in disagreement with any results known up to the present. [See Abstract No. 589 (1909).] A. W.

1529. Repartition of Energy in the D-lines of Sodium. R. Ladenburg and F. Reiche. (Comptes Rendus, 158, pp. 1788-1790, June 15, 1914.)—In his researches on the photometry of coloured flames, Gouy has discovered laws according to which the brightness of narrow lines varies with the thickness and density of the vapour. These laws are in agreement with conclusions drawn from the electronic theory of dispersion developed by the present authors [see Abstract No. 1641 (1918)]. For vapours in a very dilute state, there is a perceptible though small difference between the observations of Gouy and the author's theory. This difference can be explained by supposing that the Doppler-effect results in the repartition of energy of the D-lines in the case of dilute vapours according to the theory of Rayleigh. From the curves given it is seen that the influence of the Doppler-effect is at first to diminish the experimental values with respect to the theory of dispersion, but little by little the values pass into almost exact agreement with the dispersion theory. From this and other experiments on the velocity of the luminous centres and the damping of their oscillations, it is concluded that in very dilute vapours the coefficients of emission and of absorption of the D-lines

follow as a first approximation the function of Rayleigh ; but as the density of the vapour increases, it is found that the function of the theory of dispersion tends more and more to the repartition of energy of the D-lines, and finally predominates. A. W.

1530. *Ultimate Lines of Elements in Different Sources of Light.* A. de Gramont. (Comptes Rendus, 159. pp. 5-12, July 6, 1914.)—In previous work [Abstract No. 1344 (1907)] the author has shown that the ultimate lines of elements resist the effect of self-induction in the condensed spark, and that they are found in the arc, in the envelope of the blue cone of the Bunsen burner, in the oxy-acetylene blow-pipe flame and also in the oxy-gas blow-pipe flame. They comprise the lines which are spontaneously reversible, and disappear the last when the quantity of the element in the light source tends towards zero. The results of Hartley and Moss [Abstract No. 1696 (1912)] do not always give the ultimate lines in the sense here considered, since their observations were made by the method of decreasing the time of exposure, which is not the same as decreasing the quantity of the element present in the source of light. The effect of the temperature of the light source is dealt with, and from the study of the spectra of several substances the following laws have been deduced. Up to the present no exceptions to these laws have been discovered. (i) If in sources at different temperatures the lines of an element do not preserve the same sensibility, the ultimate lines will be, in all cases, comprised among a very small number of lines, having great sensibility in the condensed spark. (ii) The lines of max. sensibility are correspondingly less refrangible according as the temperature (or the energy) of the source is lower. A typical example of lines whose sensibility varies with the temperature of the source is furnished by the alkaline earth metals, which each present three lines of great sensitiveness in the different sparks and in the arc, lines which exhibit exactly similar characteristics from one spectrum to another. The wave-lengths are as follows :—

	<i>g</i> .	H.	K.
Ca	4226·9	8968·6	8983·8
Sr	4607·5	4215·7	4077·9
Ba	5585·7	4984·2	4554·2
Ra	4826·1	4682·4	3814·6

The results for Ra are those of Runge and Precht. For the four metals the lines H and K are the strongest in the spark ; in the arc all three lines have about the same intensity, though different numbers for the intensities have been given by different observers. The lines *g*' appear alone in the total flame of the Bunsen burner, whether observed photographically or visually. In the spark the lines H and K are the ultimate lines, K being the last to disappear ; but *g*' is of great sensibility, only slightly less than that of the others. A transformation of the same kind, though less marked, is seen in the case of the triplets of Cr and Mn. [See also Abstract No. 1527 (1912).]

A. W.

1531. *New Method for Study of Spark Spectrum.* C. de Watteville. (Comptes Rendus, 159. pp. 80-82, July 6, 1914.)—The apparatus used was similar in general principle to that previously employed by the author for the study of phosphorescence [see Abstract No. 1379 (1906)]. Modifications were made as follows : An Al disc carried at opposite ends of a diameter two metal points which could pass very close to two other points P and P', which

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were fastened to the ends of an insulating rod. One of the plates of a condenser of large capacity, worked by a transformer of the type used by Hemsalech, was connected to the point P. The other plate was connected to one of the electrodes E, between which passes the spark to be studied. The second electrode was connected to the point P'. When the disc rotates and the points pass P and P', two small sparks pass and thus allow the condenser to be discharged, the principal spark taking place behind the disc. The spark is viewed through an opening D in the disc, and the angular distance of this from the fixed points determines, in conjunction with the speed of the disc, the length of time between the passage of the spark between the electrodes E and the time of observation. By means of a lens divided into two halves along a diameter, the halves being slightly separated from one another, two small images of the spark are projected on to the disc. The shape of the opening D is such that one of these is viewed before the other, but the duration of observation of each image is the same. A single lens on the other side of the disc is used to project the two images on to the top and bottom halves of the slit of a spectroscope, so that two photographs are obtained on the same plate, the two spectra corresponding to different periods of observation after the passage of the spark. With the apparatus described the spark can be observed $1/8000$ sec. after the discharge has taken place, a worm and wheel being used to determine the speed of the disc, which can make 4000 revs. per min. A. W.

1532. *Arc and Spark Spectra of Helium*. J. Stark. (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 468-474, May 80, 1914.)—For some time past the author has been investigating the difference between the arc and spark lines of elements in their canal- and cathode-ray emission, and has shown that the arc lines are emitted by the positive singly-charged atomions of the elements, while the spark lines are emitted by positive atomions doubly- or multiply-charged [see Abstracts Nos. 982, 1288, 1960 (1918), 75 (1914).] In the present research the following results were obtained: (1) The line of wave-length 4686 \AA , which has up to the present been regarded as a hydrogen line, is emitted strongly from the positive column of the oscillatory spark in helium free from hydrogen, so it must be assigned to helium. (2) The two known series systems of helium behave in the positive column, in cathode- and in canal-rays, like arc lines. (3) The new helium line $\lambda 4686$ behaves in the positive column, in canal rays, like a spark line. (4) The peculiarities of the emission of the arc and spark spectra of helium can be explained by the fact that the former has for carrier the positive singly-charged helium atomion, the latter the positive doubly-charged atomion. A. W.

1533. *Luminous Vapours distilled from the Arc. Spectrum Series*. R. J. Strutt. (Roy. Soc., Proc. Ser. A. 90. pp. 864-872, July 1, 1914.)—It is known that mercury vapour distilled away from the arc *in vacuo* remains luminous for some distance away from the region of discharge [see Abstract No. 859 (1918)]. It is now shown how to observe brilliant effects of the same kind from a large number of other metals, including As, K, Cd, Na, Zn, Mg, Ca, Sb, Tl, Bi, Pb, Ag, and Cu. A special form of arc was used, the anode consisting of either a perforated diaphragm or a perforated plug, according to circumstances, at the upper end of a quartz tube wrapped with asbestos paper for opacity. The cathode, at the bottom end of the tube, consisted of a pool of the molten metal under consideration, melted by the heat of the arc.

The luminous vapour issued in the form of a jet from the hole in the anode. The whole apparatus was contained in a bell-jar which could be evacuated by means of a Gaede molecular pump. The appearance and general characteristics of the jet of luminous vapour observed in the case of each of the metals given above are described in detail. It is found that as the luminous vapour moves away from the region of discharge, the rate at which different constituents in the spectrum die out is not always the same. Thus, for instance, both the subordinate series of lines in the sodium spectra die out at the same rate, but the principal series dies out more slowly. The lines belonging to any given series always die out at the same rate, but another series may or may not die out at the same rate as the first. In some cases the glowing vapour distilled from the arc shows a band spectrum. The alkali metals show a continuous band beyond the limit of the subordinate series like that seen in absorption in the hydrogen stars. The present paper deals only with experimental methods of observing the luminous jets of metallic vapour distilled from the arc, and their more obvious features. In a subsequent one will be discussed the effect of an electric field in quenching the luminosity, and the inferences which can be drawn from the observations generally as to the origin of the radiation and its various spectroscopic constituents.

A. W.

1534. *Electric Analogue of Zeeman-effect.* F. Paschen and W. Gerlach. (Phys. Zeitschr. 15. pp. 489-490, May 15, 1914.)—Three different sets of experiments were made. In the first a mercury resonance lamp was so arranged that the luminescent mercury vapour was submitted to the action of an electric field in order to see whether the resonance radiation itself was subject to variation. This was analogous to the research of Malinowski, which gave his first curve [see Abstract No. 222 (1914)]. Secondly, the resonance radiation of this lamp was allowed to pass through a small absorption cell filled with mercury vapour at the room temperature, with the object of determining whether the absorption altered when the resonance lamp was submitted to the action of an electric field. This corresponded to Malinowski's second curve. Thirdly, the absorption vessel was provided with a condenser and experiments were made to see if the absorption of the light from the resonance lamp was altered by the action of an electric field on the absorbing vapour. Particulars of the apparatus are given. It was found that no appreciable variation of the absorption line could be detected, though the absorbing vapour was subject to fields ranging up to 14,500 volts/cm. Both the other researches, in which the vapour in the resonance lamp was acted on by the electric field, also gave negative results, no variation being observed. The intensity of the resonance radiation showed a variation of not more than 0.7% in fields up to 12,000 volts/cm. It appears probable that there is no variation in this case, though wave-length variations in agreement with the results of Malinowski could be obtained when a magnetic field was used. [See also Abstract No. 1598 (1910).]

A. W.

1535. *Mercury Green Line.* J. C. McLennan and A. R. McLeod. (Roy. Soc., Proc. Ser. A. 90 pp. 248-255, May 28, 1914.)—Describes measurements of the structure of the mercury line $\lambda 5461$ as resolved by glass and quartz Lummer plates, and also of the Zeeman constituents of the line. It is shown that the formula $\Delta\lambda = \Delta\lambda_m(\alpha_{s_1}^2 - \alpha_m^2)/(\alpha_{m_1}^2 - \alpha_m^2)$ is the one which should be used in measuring up the fringe pattern produced by Lummer plates for determining small changes in wave-length; α_m being the distance of a main line fringe from the central line of the pattern, α_{m_1} that of the main

line fringe of the next higher order, and a_m , being the distance from the central line of a satellite fringe of the same order as a_m . $\Delta\lambda_m$ represents that change in the wave-length of the light which would cause the fringe of the m th order of the system of fringes due to light of wave-length $\lambda + \Delta\lambda_m$ to coincide with the fringe of the $(m + 1)$ th order of the system formed by the light of wave-length λ . This formula has been applied to the determination of the positions of the satellites of the mercury line $\lambda 5461$ relative to the main component, when the line was resolved by a Lummer plate made of crystal quartz and also by two others made of glass. The results obtained with the quartz plate agree with the values recently found by Nagaoka and Takamine, who used a glass Lummer plate crossed with an echelon grating, while those obtained with the glass Lummer plates agree best with determinations previously made by McLennan with an echelon grating. Considerations are suggested in favour of the view that the green line consists of a series of lines closing together towards the centre, their position being regulated by some law which in the outer components simplifies approximately to a geometric progression. Evidence is also adduced in support of the view that a somewhat similar law applies approximately to the mercury arc line $\lambda 8841$. A method of coincidence was used to illustrate the magnetic resolution of the line $\lambda 5461$, and a value of 1.82×10^7 was obtained for e/m . [See also Abstracts Nos. 1895 (1906), 494 (1912), 424 (1913).] A. W.

1536. *Magneto-Optics of Iodine Vapour*. R. W. Wood and G. Ribaud. (Phil. Mag. 27, pp. 1009-1018, June, 1914. Journ. de Physique, 4. Ser. 5. pp. 878-887, May, 1914.)—The magnetic rotatory polarisation of iodine vapour has previously been described [Abstract No. 2082 (1906)]. The aim of the present investigation was to determine the exact nature of the rotation produced by the lines of absorption, since more recent observations have shown that the earlier results dealt with rotations produced by close groups of lines, no record having been obtained of the nature of the rotation to the right and left of a single line. It was of especial importance to determine whether the rotation to the right and left of an absorption line was of the same nature, i.e. either positive or negative, as is the case with the D-lines of sodium, or whether any case of anomalous rotation occurred—that is, positive on one side of the line and negative on the other. The absorption lines investigated are numbered 2, 3, 4, 4', 5, and 6, in accordance with the numbers used in previous papers on resonance spectra, these lines being covered by the broadened green line of the mercury arc. In this group of lines the direction of the rotation changes from line to line, which explains perfectly why the angular magnitude of the rotation is so small in comparison with that exhibited by the D-lines. The positive rotation due to a given line is nearly neutralised by the negative rotations of its two neighbours. It is also easy to see why the rotation on one side of a line may be much greater than on the other. Experiments were undertaken to see whether any evidence of a longitudinal Zeeman-effect could be observed, but no positive results were obtained. If the Zeeman-effect exists, it is less than 0.01 \AA unit for a field of 20,000 gauss. Cotton has shown that if a sodium flame is placed in a magnetic field, between crossed nicols, the light traversing it in a direction perpendicular to the lines of force is re-established in the vicinity of the D-lines, if the planes of the nicols are at 45° with the lines of force. Using the same iodine bulb as in the earlier experiments the authors have obtained a marked restitution of light, too feeble, however, to permit of its examination with an echelon. With the crater of the carbon arc as a source the restored

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light was quite brilliant, and of the same emerald-green colour as in the longitudinal experiment. Steubing has observed a diminution of the intensity of iodine vapour fluorescence in a magnetic field amounting to as much as 80 %. Using a much more powerful field the authors have succeeded in almost completely abolishing the fluorescence. The effect of the field in reducing the intensity of the fluorescence becomes more marked as the vapour-pressure of the iodine is diminished. No explanation of the effect has up to the present been obtained. The magnetic rotations of the plane of polarisation in the vicinity of absorption bands may be divided into two classes: (1) Anomalous rotations, in which the sign changes in crossing the band, as observed by Cotton for certain solutions and by Wood for a solid film of a neodymium salt. Rotations of this nature appear to obtain in cases in which there is no change in the position of the band of absorption, but merely an alteration in velocities of right- and left-handed circular vibrations. (2) Rotations in which the sign is the same on opposite sides of the absorption band, as at the D-lines of sodium and the iodine lines. Rotations of this type are explained by the division of the line into a Zeeman doublet by the magnetic field. It seems probable, therefore, that there is a small Zeeman-effect for iodine, but it is doubtful if it can ever be detected, as it is of the order of magnitude of the width of the lines, probably much less in fact. The study of the magnetic rotation of the vapour of sodium by the improved methods given in the present paper will undoubtedly give much more satisfactory results, as the rotatory power of this vapour in the red and orange is certainly ten times as great as that of iodine.

A. W.

1537. *Effect of Magnetisation on the Opacity of Iron to Röntgen Rays.* **A. H. Forman.** (Phys. Rev. 8. Ser. 2. pp. 806-818, April, 1914.)—The method adopted to investigate this subject proved very sensitive, and was capable of detecting a change in the opacity of one part in 10,000 under the most favourable conditions. Tests, in which the iron was magnetised in a plane perpendicular to the Röntgen rays, with its direction of magnetisation parallel to the axis of the X-ray tube, and also with its direction of magnetisation perpendicular to this axis, gave negative results. The method is now being extended to investigate the effect of applying a magnetic field parallel to the Röntgen rays and perpendicular to the plane of the iron. The high degree of sensibility obtained suggests that the method might be useful in other fields of research where the changes sought for are likely to be quite small.

E. A. O.

1538. *Spectra of Secondary X-Rays.* **M. de Broglie.** (Nature, 98. p. 849, June 4, 1914.)—Hitherto X-ray spectra have been obtained by using the substances, whose spectra are required, as antikathodes inside a discharge tube. The author points out that the same end may be achieved by simply allowing a beam of X-rays from an ordinary bulb to fall on the substance whose spectrum is required, and afterwards examining the secondary rays emitted by it. Photographs of the spectra of zinc, copper, mercury (amalgam of zinc) were taken in this way without any trouble. Zinc amalgam showed five rays: two due to Zn, two due to Hg, and one due to some impurity (probably Fe). An experiment conducted with the substance contained in a thin paper bag was very striking. Using zinc oxide inside the bag, the presence of zinc was immediately made manifest. The author observes that the method promises to be particularly useful for experiments in which the rays to be examined are emitted under various conditions.

E. A. O.

1539. *Intensity of Interference Spots with Zincblende and the Zincblende Space-grating.* P. P. Ewald. (Ann. d. Physik, 44, No. 2, pp. 257-282, May 12, 1914.)—The object of the paper is to test the correctness of the Bragg models for a variety of crystals by showing that the transmission photographs can be predicted from such models. Sommerfeld treated of the diagrams with three-fold and four-fold axes (Solway Congress, Brussels, 1918). The present paper deals also with the two-fold axis diagram and oblique transmission. As basis for the verification are taken the following facts. (1) The incident beam consists of a continuous spectrum, for otherwise a slight tilt would cause the pattern to alter completely. (2) There is a lower limit to the value of λ/a (where a = grating constant) for otherwise the whole plate would be blackened. (3) There is also an upper limit to the wave-length, though this does not reach as high as $\lambda = a$. It is shown that all the spots to be expected from the postulated crystal structure in view of these restrictions in wave-length actually appear. The intensities of the spots are connected together in a regular manner, for they can be shown to be in accordance with a distribution in the primary beam, represented by a smooth curve. Since the strong part of this curve embraces only about one octave, it is only necessary to insert the intensity of an interference spot in the curve in order to determine the wave-length giving rise to the spot. Absolute numerical correspondence is vitiated by the influence among other things of absorption and heat motion. The zincblende crystal structure is considered in detail. From Bragg's reflection data the structure appeared to be a face-centred cube of zinc atoms with the sulphur atoms disposed in an exactly similar configuration, and removed from the zinc atoms one-quarter of the way along the diagonals of the zinc cubes. Thus, if the side of a cube be represented by $4(a=4)$, the zinc atoms are completely represented by

$$\begin{array}{lll} X \equiv 0 & Y \equiv 0 & Z \equiv 0 \\ X \equiv 2 & Y \equiv 2 & Z \equiv 0 \\ X \equiv 2 & Y \equiv 0 & Z \equiv 2 \\ X \equiv 0 & Y \equiv 2 & Z \equiv 2 \end{array}$$

while the sulphur atoms are completely represented by the co-ordinates resulting on adding 1 to each of the above co-ordinates. The intensity of any interference ray resulting from a face-centred cube is easily shown to be proportional to

$$(1 + e^{i\pi/2(2h_1 + 2h_2)} + e^{i\pi/2(2h_1 + 2h_3)} + e^{i\pi/2(2h_2 + 2h_3)}),$$

where h_1 , h_2 and h_3 are the orders of interference in the three principal directions in the crystal. This factor can only be equal to 4 or 0, the latter occurring when the three indices are partly even and partly odd. The sulphur atoms being also arranged in face-centred cubes give the same interference pattern, but not necessarily the same intensity. The above factor has therefore to be multiplied by $(1 + A e^{i\pi/2(h_1 + h_2 + h_3)})$. If A is equal to unity, the latter factor becomes zero for $h_1 + h_2 + h_3 = 4n + 2$. This case is realised in the diamond. Since in zincblende $A < 1$ a considerable diminution in intensity in these spots takes place instead of complete obliteration. The complete systems of interference points for the diagrams with four-fold, with three-fold and with two-fold axes are enumerated, using as "enumerating-index" h_s , $s(=h_1 + h_2 + h_3)$ and $\sigma(=h_2 + h_3)$ in the three cases respectively. In making this enumeration, limits are set to the values of $2a/\lambda$ (between 16 and 60), of $s(=h_1^2 + h_2^2 + h_3^2 < 100)$ and of ϕ (angle

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between incident beam and interference ray $< \pi/4$). Against each point so found is placed the intensity actually found in the photographic records of Friedrich and Knipping, and finally the intensity is plotted against wave-length as calculated in the above enumeration. In every case the intensity is found to lie on the same smooth curve, although the absolute ordinates of the curve may depend on the "enumeration-index." This curve thus constitutes an analysis of the incident beam showing a maximum at $2a/\lambda = 82$. A few points lie completely away from the curves, the ordinates being far too small. These prove to be those mentioned above where $h_1 + h_2 + h_3 = 4n + 2$, thus affording striking confirmation of Bragg's model for zincblende. The lack of correspondence between the curves and the true distribution of energy in the primary X-ray spectrum depends upon the relative preponderance of the absorption factor, the index-factor (Debye-Lorentz), and the heat-motion factor. In the oblique transmission photograph not only are the positions of the spots altered, but the wave-lengths corresponding to them are also changed. Knowing the intensity distribution in the primary beam we should be able to predict the relative intensity of the various spots in the two photographs. This practical test shows complete agreement with theory. The crystallographic properties of the Bragg models for zincblende and diamond are also shown to be in accordance with reality.

E. A. O.

1540. *New Diffraction Photographs.* M. E. Hufford. (Phys. Rev. 8, Ser. 2 pp. 241-248, April, 1914.)—If monochromatic light from a point source is made to pass through a circular opening and fall upon a screen, and if the size of the opening is chosen so that the difference in optical paths by way of the boundary and by way of the centre of the opening is some whole number of half wave-lengths of the light used, then in the illuminated area where the paths end, there will be interference. This is verified by photographs of the diffraction patterns obtained from a series of openings varying consecutively from 1 to 25 half-period elements in size, the light chosen being the intense fluting, beginning at wave-length 8880×10^{-8} cm. in the spectrum of the carbon arc. The second portion of the paper deals with the properties of the Arago white spot at the centre of the geometric shadow of a large disc or sphere. The very large bright spots obtained showed that each point in the aperture produces a corresponding effect in the shadow, which suggests that the aperture may be any sort of figure, and in the shadow of the disc or sphere there should be an inverted image of it. The result of experiment proved this to be the case. From the plates given in the paper it is seen that, with sufficient contrast on a photographic transparency, the transparency may be actually reproduced by using an opaque disc or sphere in place of a lens. The definition of the diffraction pattern thus obtained is surprisingly good.

E. A. O.

1541. *X-Rays and Crystalline Structure.* W. H. Bragg. (Engineering, 97. pp. 814-815, June 12, 1914. Discourse delivered at the Royal Inst.)—A general summary of recent results in this branch of investigation.

1542. *Ionisation of Water-vapour by α -Particles.* B. Bianu. (Le Radium, 2. pp. 65-69, March, 1914.)—The experiments deal with a determination of the ranges of the α -particles of polonium in saturated water-vapour at temperatures between 75° and 100° C. The product $a \times d$ was found to be constant and equal to 0.00875, where a is the range and d the density in gm./cm.³.

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From the total areas of the Bragg ionisation curves it was found that the total ionisation in water-vapour is practically equal to that in air—as might have been predicted from considerations of chemical composition—and, further, the range was in accordance with Bragg and Kleeman's square-root law. Anomalous results were, however, obtained in experiments on ionisation by collision in water-vapour.

E. M.

1543. Wave-length of the Soft γ -Rays from Radium B. E. Rutherford and E. N. da C. Andrade. (Phil. Mag. 27. pp. 854-868, May, 1914.)—The γ -rays from a thin-walled α -ray tube, filled with a large quantity of radium emanation, were allowed to fall at a definite angle on a crystal, generally rocksalt, and the intensities of the "reflected," or rather, diffracted, rays were examined by a photographic method. Difficulties were encountered owing to (1) the long exposure necessary; (2) the direct action of the penetrating γ -rays from RaC which had to be screened by thick pieces of lead, and (3) the effect of the primary and secondary β -rays. The effects of the latter were reduced by placing the source and crystal in a magnetic field of 2500 gauss. In the present experiments only the soft rays, known to come from RaB have been investigated, since these were found to be reflected at convenient angles. The results are shown in the following table.

RADIUM B. Soft γ -ray Spectrum.			PLATINUM. X-ray Spectrum.
Angle of reflection from Rocksalt.	Wave-length (in cm.).	Intensity.	Angle of reflection 1°122
8° 6'	0.798 $\times 10^{-8}$	m.	
8° 16'	0.809	m.	
8° 34'	0.838	m.	8° 27'
8° 48'	0.858	m.	8° 43'
9° 23'	0.917	f.	
9° 45'	0.958	m.	
10° 8'	0.982	s.	10° 2'
10° 18'	1.006	m.	10° 18'
10° 32'	1.029	m.	
10° 48'	1.055	f.	
11° 0'	1.074	f.	
11° 17'	1.100	f.	
11° 42'	1.141	m.	
12° 8'	1.175	s.	12° 8'
12° 16'	1.196	m.	
12° 31'	1.219	f.	
18° 0'	1.266	f.	
18° 14'	1.286	f.	
18° 31'	1.315	f.	
18° 52'	1.349	m.	
14° 2'	1.365	m.	

It will be seen that the γ -ray spectrum is of the same general type as that found by Moseley, etc., when platinum is bombarded by kathode rays (Column IV).

Recent work has shown that RaB is identical in chemical properties with Pb, and on the nucleus theory of an atom this is explained by assuming that the central charges are the same. On this idea RaB ought to give an X- or γ -

ray spectrum almost identical with that of lead. From Moseley's results lead ought to have a central charge of $82e$ [Abstract No. 1249 (1914)], and ought to give the main line in the X-ray spectrum reflected by rocksalt at an angle of 12.07° . The strongest line of RaB was found to be reflected at 12.05° —a very close agreement. In further experiments the γ -ray spectra of RaB and lead were compared under as nearly as possible identical conditions. The spectrum in the latter case was obtained by exciting γ -rays in a thin strip of lead by allowing a strong pencil of β -rays to fall on it. Owing to experimental difficulties only two lines of lead could be measured. These gave angles of reflection of $10^\circ 2'$ and $12^\circ 0'$ in good agreement with the strong lines of the RaB spectrum.

The bearing of these results on the structure of the atom is discussed.

E. M.

1544. β - and γ -Rays and the Structure of the Atom. A. van den Broek. (Nature, 98, pp. 876-877, June 11, 1914.)—The paper deals with empirical and theoretical considerations of the values given by Rutherford and Robinson [Abstract No. 251 (1914)] of the velocities of the pencils of β -particles emitted from RaB, and also of the wave-lengths of the γ -rays of RaB given by Rutherford and Andrade [see preceding Abstract]. It is found that the frequencies of the γ -rays are nearly proportional to the squares of the integers between P [periodic number = 60, as determined in Abstract No. 569 (1914)] and $A/2$ (half the atomic weight, 107), and that the β -ray spectrum contains only velocities proportional also to integers between P and $A/2$. The author concludes from this that the radii of the inner electrons are all different, thus forming a "planetary" rather than a "saturnian" atom [cf. Nicholson, Abstract No. 1246 (1914)]. Thus different elements ought to have partly identical β - and γ -rays and the so-called β -ray spectra might consist of electrons expelled by the β -particles and not of the β -particles themselves. The author further suggests an alteration of Moseley's formula [Abstract No. 1249 (1914)] based on the above idea.

E. M.

1545. The Origin of Actinium. O. Göhring. (Phys. Zeitschr. 15, pp. 642-645, June 15, 1914.)—It is now generally accepted that actinium is a relatively short-lived element with a half-time value of the order of magnitude 100 years, and that it cannot therefore be a primary radio-active element, but must have a long-lived parent substance. It seems also certain that there must be a genetic connection between the Act series and the Ur-Ra series. The present experiments have been made in an unsuccessful attempt to separate the parent of actinium.

A. E. G.

1546. Uranium Y. O. Hahn and L. Meitner. (Phys. Zeitschr. 15, pp. 236-240, March 1, 1914.)—The authors study the substance found associated with UrX when prepared by the iron method. This was called Uranium Y by Antonoff [Abstract No. 1684 (1911)]. They confirm its existence, although it has the same chemical properties as UrX, by its half-period of 25.5 hours and its emission of slow β -rays. UrY is produced either by Ur_1 besides UrX, or by Ur , besides ionium.

E. E. F.

1547. Radio-activity of Springs near Williamstown, Massachusetts. J. E. Shrader. (Phys. Rev. 8, Ser. 2, pp. 889-845, May, 1914.)—A warm spring near Williamstown has been found to contain radium. The paper describes apparatus used for determining the radio-activity of the water, and a number of results of tests made on other springs are given.

H. H. H.

HEAT.

1548. *Van der Waals' Equation and Nernst's Theorem.* L. Schames. (Deutsch. Phys. Gesell., Verh. 16. 11. pp. 518-528, June 15, 1914.)—A theoretical treatment based on the researches of various investigators. It appears (1) that for diatomic and triatomic gases (perhaps also for monatomic gases) the value of the specific heat at the critical temperature is just twice that at absolute zero. (2) In place of the gas constant in van der Waals' equation the integral value of $C_p - C_v$ should be substituted. (3) Nernst's theorem is extended; for condensed systems when $T = 0$ and $p = 0$ the energy is independent of the state of aggregation or of its modification. This leads to the adoption of two other critical points: (i) solid-undercooled fluid, where $p = 0$, $T = 0$; and (ii) solid-fluid where $p = \infty$, $T = T_k$, T_k being the temperature of the ordinary critical point. (4) It appears that for water the energy contents at the points named above have simple ratios to each other. At all events, for the ordinary critical point, U being the thermodynamic energy, $U_k = U_o$. (5) Nernst's theorem is part of a more general one, that at the critical points the differential coefficients of the quantities defining the physical state attain extreme values. A. W.

1549. *Radiation and the Quantum Theory.* J. H. Jeans. (Physical Soc. Publication, [90 pp.] London, 1914.)—This is a general report on the present state of the problem, dealing in seven chapters with: The need for a quantum theory: The radiation problem on the basis of Newtonian mechanics: Development of the quantum theory: Line spectra: Photoelectric effect: Specific heat of solids: Physical basis for the quantum theory. Something in the nature of the quantum theory is imperatively demanded by the observed facts of full radiation unless the possibility of thermodynamic equilibrium between matter and ether, or alternatively, the very existence of the ether, be denied. The latter alternative, with its consequent repudiation of a constant speed of radiation through the ether, leads, as the relativity controversy has shown, to the subversion of our fundamental concepts of space and time. In the radiation problem the Newtonian mechanics suffice so long as $h\nu/RT$ is small, *i.e.* so long as the average energy RT of a vibration contains many quanta. Moreover, the quantum theory supplies explanations in other phenomena where only one or a few quanta are concerned, *e.g.* The line spectra of hydrogen, helium, and perhaps lithium (Bohr's theory): Photoelectric phenomena, including the infra-red band apparently characteristic of all substances: The decrease of atomic heat to vanishing-point at the absolute zero temperature (Debye's theory), and the identity of the temperature-atomic heat curves, for all substances (except for differences of temperature scale). In all these cases the Newtonian mechanics fail. The quantum theory, however, appears from Poincaré's investigation [Abstract No. 841 (1912)] definitely to involve some kind of atomicity either of energy or of action (energy \times time), and this seems to be absolutely irreconcilable with the undulatory theory of light, and presents other considerable, if less formidable, difficulties. At present there is no solution of these difficulties in sight, but the author points out that no physical explanation has yet been found for the atomicity of e , and suggests that a greater knowledge of the

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nature of the equations of the ether may possibly show that they contain the quantity c , and possibly that this is the same thing as saying that they contain the quantity h . It might then appear that the Newtonian mechanics represent an approximation holding good for the larger scale phenomena, where they have hitherto been found reliable, but are not applicable to the small-scale phenomena in which electrons and light-waves are directly involved.

G. W. DE T.

1550. *Thermodynamics of Radiation.* H. L. Callendar. (Phil. Mag. 27. pp. 870-880, May, 1914.)—In his previous communication [Abstract No. 286 (1914)] the author's proposed formula for full radiation was derived from a quasi-molecular theory of radiation with free use of the close analogy between full radiation and an ideal vapour. An alternative method is here given starting from the generally accepted fundamental facts: (1) The condition within a vacuous enclosure at constant temperature T is representable by an isotropic energy stream Q per sec. per sq. cm., which is a function of T only. (2) This will hold for each separate frequency γ , giving partial energy streams q , which are functions of T and γ only. (4) The full and partial energy densities per cm.³ at any moment will be $4Q/c$ and $4q/c$, respectively, where c is the velocity of light. (5) As a perfectly reflecting sphere filled with homogeneous and isotropic radiation of different frequencies expands with a speed small as compared with c , the wave-length of every component will increase proportionally to the radius (Doppler-effect). (6) In adiabatic compression the whole energy of each component which retains its identity will vary as its frequency. This is the simplest assumption for the variation of energy and agrees with electromagnetic theory, and it follows that the whole energy varies as $1/r$, so that $r^4 q d\gamma$ is constant. (7) The radiation pressure $p dv$ due to the stream $q d\gamma$ is deducible by equating the work in a small expansion dr to the energy loss of the stream, giving $p = 4q/8c$, and for the whole radiation, $P = 4Q/8c$, the pressure and the work resulting essentially from change of frequency due to Doppler-effect. (8) Full radiation remains such in adiabatic change, and so by Carnot's principle T varies as the frequency of each component, and therefore as $1/r$. The energy density of the pressure then varies as T^4 for the radiation as a whole and for each component (Stefan-Boltzmann law), and λT , or γ/T , is constant for each component (Wien's law). Both laws are summed up in Wien's expression $q = C\gamma^3 F(\gamma/T) = CT^3 f(\gamma/T)$, where F and f are undetermined functions expressing the distribution in full radiation.

Now each frequency seems to travel without change in free space, so that Carnot's principle should apply to each energy stream q , and its latent heat of isothermal emission should therefore be $T(d p/d T)_\gamma$, which is not proportional to q as is generally assumed. This conclusion is shown to follow from the Doppler-effect in adiabatic expansion, instead of being in conflict with it. The entropy will then be $(d p/d T)_\gamma$, and the intrinsic energy (E/v in previous paper) is $T(d p/d T)_\gamma - p$, and then, from Wien's law, E/pv must be a function of (v/T) , depending on the distribution. Its form was assumed to be bv/T , on the ground that intrinsic energy varies as frequency. This leads to the simplest relations; has been shown to agree in fundamentals with atomic theory; and is here shown by the author to agree satisfactorily with experiments.

G. W. DE T.

1551. *Radiation and the Quantum Theory.* J. Duclaux. (Comptes Rendus, 158. pp. 1879-1882, June 22, 1914.)—The author argues, on the basis
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of his identification of Planck's quantum with a definite "element of energy" involved in the formation or rupture of an atomic bond [Abstract No. 888 (1918)], that transference of energy between ether and matter may take place continuously whenever there is no such rupture, *e.g.* in monochromatic radiation and in the absorption of light by cold bodies. The identification would enable our extensive knowledge of chemical phenomena to be used for the interpretation of the radiation phenomena, of which we are comparatively ignorant.

G. W. DE T.

1552. *Gas Theory*. A. Rosenthal. (Ann. d. Physik, 48. No. 6. pp. 894-904, March 20, 1914.)—Investigates the utility of P. and T. Ehrenfest's "quasi-ergode" hypothesis (Enzykl. d. Math. Wiss. 5, 2 (82) No. 10A), which may be expressed as follows: Every gas is a quasi-ergodic system, *i.e.* a single undisturbed motion of the system, if continued indefinitely, approaches indefinitely (not "passes through," as originally postulated in the original ergode hypothesis) every physically possible point of the energy surface of the total gaseous energy. The author shows that the gas theory may be built up in a simple manner upon this hypothesis.

E. E. F.

1553. *New Relation between the Critical Quantities: Unity of all Substances in their Thermal Behaviour*. J. J. van Laar. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 924-988, April 28; and pp. 1047-1064, May 29, 1914.)—The author discusses, with various examples, means of determining the shape of the function, $b=f(v)$ [see Abstract No. 1284 (1914)], various complicated expressions being derived which fulfil all the necessary conditions.

T. H. P.

1554. *Vapour Pressure Lines of the System Phosphorus*. I. A. Smits, S. C. Bokhorst, and J. W. Terwen. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 1174-1186, May 29, 1914.)

1555. *Character of Luminous Metal Vapours in Flames*. H. Kohn. (Ann. d. Physik, 44. No. 5. pp. 749-782, June 19, 1914. Extract from Dissertation, Breslau.)—The author has made experiments with the view of ascertaining if the light emitted by luminous metallic vapours in a Bunsen flame follows Kirchhoff's law and hence consists of temperature rays. The current passing through a Nernst lamp, the image of which falls on the luminous flame, was adjusted until the spectrum of the flame on the continuous spectrum of the Nernst lamp just disappeared. The flame will then be a temperature radiator if the dark temperature of the flame coincides with the temperature of the Nernst lamp. The temperature of a Pt-Rh wire hung in the flame was measured pyrometrically and was found to be lower than that of the Nernst lamp. This is due to the fact that the wire is cooler than the surrounding flame in consequence of its greater radiation. When the wire is heated electrically until its temperature coincides with that of the Nernst lamp, it is found that this temperature is also that of the flame within $\pm 10^\circ$. It is therefore demonstrated that metallic vapours are temperature radiators and that the emission of light does not depend on luminescence. This is the case both with the hot flames of illuminating gas and also with these flames cooled to about 1250° by introduction of CO_2 . On the other hand, with the cold flames obtained by burning suitable mixtures of carbon disulphide and air, luminescence, seems to occur at about 670° .

T. H. P.

1556. *New Method of Using the Fery Radiation Pyrometer.* G. Millochau. (Comptes Rendus, 159. pp. 171-174, July 18, 1914.)—The author shows how the Fery radiation pyrometer by means of readings made with and without an absorbing screen can be used for the determination of temperatures when the image produced by the telescope is smaller than the disc of the instrument. Readings made in this way agree to within 20° with readings made with the whole of the disc illuminated. F. J. H.

1557. *Electrical Ignition of Gaseous Mixtures.* W. M. Thornton. (Roy. Soc., Proc. Ser. A. 90. pp. 272-297, May 28, 1914.)—The author has studied the ignition of mixtures of air with various gases and vapours by means of direct- and alternating-current break sparks between iron and, in some cases, nickel poles.

Direct Current.—The higher the voltage, the less the current required for ignition; the curves obtained closely resemble the characteristics of steady arcs, which are known to be maintained by ionised vapour between the poles, and they have the same form at all percentages between the inflammable limits. With the paraffins, methane, ethane, propane, butane, and pentane, the change of susceptibility to ignition varies with the percentage of gas in the same manner in all cases. Each curve has three distinct portions, that which gives the peculiar form being a straight line passing through or nearly through zero and indicating that over the greater part of the range of inflammability the least igniting current is very closely proportional to the absolute number of molecules of combustible gas in unit volume of the mixture. At the lower limit is a steep branch showing that the transition from the most inflammable mixture to that which cannot be ignited is sudden. The upper limit is approached rather more gradually. The curves also indicate: (1) That the same igniting current, that is, the same energy, is required for each most inflammable mixture, in spite of the great difference between the calorific values of methane and pentane; (2) that there is no square law, except at the limiting mixtures, and (3) that the most inflammable mixture is not always that in the proportions required for perfect combustion, but sometimes contains air in excess. It is clear that combustion is an important factor even in the initial stage, yet there is evidence that the influence of the discharge from the spark, whatever its nature, acts directly upon the atoms in a molecule rather than upon the molecules as a whole.

Measurements made with the simple alcohols show that the slope, I/p —where I represents the igniting current and p the percentage of combustible gas present—of the base of the curve is slightly decreased by the addition of the oxygen atom to the paraffin molecule, so that the inflammability of the vapour measured by this slope is lower. Further, with both iron and nickel poles, the alcohol of greater molecular weight requires the greater current for ignition. Here, too, the ratio $I:p$ is proportional to the number of atoms, n_{C+H} , of combustible gas in the molecule more nearly than to the calorific value. The curve for benzene has no straight part, and is nearly symmetrical within the limits of combustibility. The most sensitive mixture contains about 4.8 % of benzene, combustion to CO requiring 4.47 %. The same form and position of the curve are found with alternating as with continuous current. The evidence is therefore strong that in so far as the magnitude of the igniting current is an indication of the atomic charges occurring at the instant of explosion, CO is the chief and first product of combustion, the formation of CO_2 being a much slower process than with lighter gases. The after-burning of benzene may account for the fact that benzole fuel gives less

shock than petrol, the combustion being less sudden and extended more over the stroke. With carbon disulphide, the igniting current is extremely small, viz. 0.82 amp., and the mixture giving complete combustion is nearly the most inflammable one. The glass discharge tube from the explosion vessel becomes rapidly coated with sulphur after the ignition, a high state of atomic dissociation of the combining gas during the explosion being thus indicated. Carbon disulphide being an endothermic compound, the supply of heat to it by the combustion of a small portion of the mixture or from the arc may cause the rest to explode with liberation of free carbon and sulphur. The explosion is violent with all mixtures. With hydrogen the ignition current is the same for all mixtures except towards the limits of inflammability, so that the ignition is an isolated molecular process, independent of concentration and requiring only a certain intensity of molecular movement for its production. The CO curve differs slightly from the hydrogen curve, and these two show, as it were, the genesis of the straight-line type from a parabola symmetrical between the limits of inflammability. Increase of the circuit voltage has no influence on the position of the point of greatest inflammability, but is accompanied by regular and rapid diminution of the slope of the curve. At voltages over 100, the igniting current is nearly the same over the whole range of inflammability, this being an important point in the working of internal combustion engines. The period known as the time of explosion appears to be capable of a simple mechanical explanation, the square law followed by petrol indicating that the "explosive unit" is there large compared with the mass of inert gas, while the higher limits of inflammability of simple gases are due to the smaller volume and mass of the explosive unit.

Alternating Current.—The differences between the results obtained with continuous and alternating currents arise from the dragging of the electrons or ions across the spark from pole to pole and the prevention of their escape into the gas. Alternating igniting currents have therefore to be much greater than continuous currents at the same voltage. This difference is increased by the approach of the period of the current to the time of duration of the break-spark. The latter varies with the voltage so that the igniting current remains constant over a wide range of voltage. The igniting currents of the paraffins increase as the order rises, the product of the minimum current for each gas and the percentage at which it occurs being constant. The product of the number of atoms in a molecule of combustible gas and of the above percentage is also constant, so that the number of atoms in unit volume in all the most inflammable mixtures is the same. The igniting current is most nearly proportional to the number of atoms in the group of one molecule of combustible gas and the oxygen required for combustion, forming an explosive unit. The paraffin gases after methane are most easily ignited at a percentage giving combustion midway between CO and CO₂, and both limits of inflammability are symmetrical from this point. Benzene is most easily ignited when burning to CO, alcohol to CO₂. Carbon disulphide and hydrogen have the forced or continuous-current type of ignition. External ionisation which does not itself cause ignition has no measurable influence on the least igniting currents by break-sparks.

From the great differences in magnitude and type between continuous- and alternating-current ignition, it seems probable that ionisation of some kind precedes combustion. That a gas has a particular temperature of inflammation may mean that ionisation by collision begins at this temperature, with absorption of energy from the source, or, later, from that liberated by recombining atoms. Thus, when the molecular energy set free by com-

bustion of a molecule exceeded that required for initial ionisation of an adjoining molecule there would be true explosion, and since it is probable that all three modes of molecular motion, translation, rotation, and vibration, take part in the process of ionisation by collision, the influence of temperature, depending only on the translational energy may be in certain cases of secondary importance.

T. H. P.

1558. *Heat Conductivity and Viscosity of Monatomic Fluids.* L. Brillouin. (Comptes Rendus, 159. pp. 27-30, July 6, 1914.)—Following theory given previously by Debye and by M. Brillouin [see Abstract No. 446 (1918)], a formula is developed for the heat conductivity of a fluid. From this formula it appears that the conductivity becomes very great at very low temperatures. Formulæ are also obtained for the coefficient of viscosity of deformation and of viscosity of compression of a fluid, which of course are the same for gases.

A. W.

1559. *Ratio of Specific Heats of Chlorine.* J. R. Partington. (Phys. Zeitschr. 15. pp. 601-605, June 15, 1914.)—Measurements are made of the velocity of sound in chlorine by the modified Kundt tube method as used by Behn and Geiger [see Abstract No. 249 (1908)]. This gives the "ideal ratio of specific heats" from which by formulæ already deduced by the author from the Berthelot characteristic equation [Abstract No. 691 (1914)] the true values of the molecular heats and their ratio are deduced. The values obtained are $C_p = 8.49$ cals., $C_v = 6.89$ cals., and $C_p/C_v = 1.829 \pm 0.001$.

F. J. H.

1560. *Specific Heat of Metallic Alloys consisting of Solid Solutions.* L. Rolla. (Accad. Lincei, Atti, 28. pp. 616-621, April 19, 1914.)—It has been shown by Koref [Abstract No. 948 (1912)] that Lindemann's formula gives the specific heats of compounds if the corrected vibration frequencies corresponding with the melting-points are inserted. The author has investigated the melting-point diagrams of a number of alloys of Ag-Au, Cu-Au, Cu-Ni, Ni-Mn, and Cu-Mn, and has calculated their specific heats by the above formula. The values thus obtained are compared with those measured directly by means of Koref's copper block calorimeter (-190° to 0°) or Schottky's toluene calorimeter (0° to 25°). The agreement between the two sets of numbers is only moderately good, but gives a qualitative indication of the existence of curves of atomic frequency.

T. H. P.

1561. *Specific Heat of Helium.* A. Eggert. (Ann. d. Physik, 44. No. 4. pp. 643-656, June 4, 1914. Extract of Inaug. Dissertation, Marburg, 1910.)—The specific heat of helium at constant pressure is determined at -15° , $+50^\circ$, $+100^\circ$, and $+150^\circ$ C. by the Regnault method; the mean value between -15° and $+150^\circ$ being given as $C_p = 1.2662 \pm 0.0011$. The object of the investigation was to test the atomicity of He from the formulæ $M \cdot C_v = M \cdot C_p - 2.004$ and $A \cdot C_v = 8.008$ given by Richarz, where M and A are the molecular and atomic weights, and C_p and C_v the specific heats of the gas at constant pressure and constant volume respectively. Helium is shown to be monatomic and the value of the ratio of the two specific heats as calculated from the measured value of C_p and the above value of $A \cdot C_v$ shows good agreement with well-known direct measurements. The observations agree fairly well with those of Scheel and Heuse [Abstract No. 827 (1913)], but show no variation with temperature within the limits of experimental error.

F. J. H.

1562. Leonard Weber's Photometer as an Optical Pyrometer. A. Repiewa. (Russian Physico-Chemical Soc., Journ. 45. 7. pp. 862-870, 1918.)—The use of the Weber photometer for the measurement of high temperatures is based on the formula, $E = C_1 \cdot \lambda^{-5} \cdot e^{-C_2/\lambda T}$, expressing the relation between the light, E , emitted by an absolutely black body, its absolute temperature T and the wave-length λ , C_1 and C_2 being constants and e the base of the natural system of logarithms. It is shown that, if E_1 and E_2 are the values of E corresponding respectively with λ_1 and λ_2 , $\log(E_2/E_1) = A - B/T$. Thus the relation between E_2/E_1 and $1/T$ is expressed graphically by a straight line. A magnitude proportional to E_2/E_1 may be measured by means of the Weber photometer. Thus, if the intensity of the emitted light passing through a red glass (E_{rd}) and through a green glass (E_g) be measured, $E_{rd} = C_{rd} \cdot R^2/r_{rd}^2$ and $E_g = C_g \cdot R^2/r_g^2$, where C_{rd} and C_g are constants for the given photometer, R is the distance, constant in both cases, of the source of heat from the screen, and r_{rd} and r_g are the distances of the screen from the lamp. From this it follows that, $r_{rd}^2/r_g^2 = KE_g/E_{rd}$ and $\log(KE_g/E_{rd}) = A_1 - B/T$, where $A_1 = A + \log K$. A_1 and B being known, measurement by the photometer of KE_g/E_{rd} gives T . In order to determine A_1 and B , the photometer was calibrated by means of a zirconium lamp, through which was passed a current, varied by a rheostat.

T. H. P.

1563. Actual and Black-body Temperatures. C. C. Bidwell. (Phys. Rev. 8. Ser. 2. pp. 489-449, June, 1914.)—Comparisons are made between the actual and black-body temperatures of Fe, Au, Ag, Cu, and Ni, both solid and liquid, over the range 1000° to 2000° abs. Except in the case of iron which was heated in a crucible, the specimen was heated in a cavity cut in a carbon rod heated electrically, the surface of the metal protruding slightly beyond the carbon surface. The carefully calibrated Morse optical pyrometer, in which light as nearly as possible monochromatic of wave-length 0.66μ was used, was directed towards the metal surface and towards a neighbouring air cavity in quick succession, the readings giving the black-body and the actual temperatures respectively. Independent readings of actual temperatures were also made by means of carbon-graphite thermo-couples [see Abstract No. 1602 (1914)], which confirmed the cavity measurements. By means of Wien's law the relative emissivities were calculated, the results being plotted against the actual temperatures. When the solid surface was obtained by freezing the molten metal, care being taken to avoid all traces of oxide, continuous curves were obtained for the passage from the solid to the liquid state. Solid surfaces prepared artificially always showed a sudden drop in emissivity on melting. The relative emissivities of Au, Cu, and Ag are very small and practically independent of temperature except at the highest temperatures where a slight increase with increasing temperatures was found. Solid iron has a fairly constant emissivity, but that of solid nickel decreases with increasing temperature, the coefficient being 0.000125. With both molten iron and molten nickel there is a rapid increase in emissivity with temperature; this the author attributes to the solution of carbon. The values of the relative emissivity agree well, except in the case of iron, with those of the coefficient of absorption at 25° C. found by Rubens and Hagen.

F. J. H.

SOUND.

1564. Architectural Acoustics. F. R. Watson. (University of Illinois, Bull. 11. No. 78. pp. 8-29, March 16, 1914.)—A general survey of present knowledge of this subject together with a special examination of the defective acoustics of the auditorium of the University of Illinois and its treatment.

The chief trouble in defective halls usually arises from reverberation and echoes. The former is the common defect and refers to the slow decadence of sound from the many reflections occurring at the hard smooth surfaces of its walls before the energy is dissipated. The obvious cure is to have rougher, more porous surfaces, *i.e.* covering the walls and floor with hangings and carpets. W. C. Sabine deduced from his experiments that t , the time of reverberation, was given by $t = 0.164V \div a \dots (1)$, where V is the volume of the room and a the absorbing power of the different materials present, the following being the chief values for a .

One Square Metre of Surface:	a .
Window space	1
Glass, plaster, or brick.....	0.025
Heavy rugs, curtains, etc.	0.25
Hair felt, 1 in. thick.....	0.75
Audience	0.96

W. S. Franklin theoretically obtained the formula $t = 0.1625V \div a \dots (2)$.

Distinct echoes may also occur in a hall, and these may be removed or rendered less objectionable by changing the angle of the walls which produce them or by covering these walls with absorbent materials. The author has not discovered a single case in which the installation of wires has resulted in any pronounced improvement. Reflecting or sounding boards may be used with advantage if specially arranged to suit the particular case. The heating and ventilating arrangements may also affect the acoustics of a hall, but usually the differences of temperature and of speeds are too small to have any marked influence.

The auditorium at Illinois was dome-shaped and had many subordinate curved surfaces which focused the sounds in an objectionable manner. After a complete exploration of its behaviour several remedies were applied. The mean time of reverberation determined from nearly 400 observations was 5.90 secs. ; calculated by Sabine's formula ($V = 11,800$ cub. m.), this time came out as 6.4 secs.—a good agreement. Thick carpets were placed on the stage, heavy velour curtains 18×82 ft. hung on the wall at the rear of the stage, a large canvas painting (400 sq. ft.) was introduced, and the glass removed from the skylight in the ceiling. This reduced the time of reverberation of the hall when empty to 4.8 secs. With an audience present this value was reduced still more, and when the hall was crowded the reverberation was not troublesome. Pronounced echoes, however, still gave trouble. These were prevented by draperies hung in the dome.

As to the use of a sound-board, one was constructed of plaster in a parabol. xvii.—A.—1914.

boloidal form and acted well for a single speaker, but some objected to its appearance ; also it was useless for a chorus or band, so that it was discarded.

E. H. B.

1565. *Vibrations Proper to Coupled Systems.* P. Debye and J. Kern. (Phys. Zeitschr. 15, pp. 490-497, May 15, 1914.)—A mathematical paper whose chief points are as follows :—(1) For continuous systems M. Born established the theorem that the acoustic spectrum of a double system may be regarded as the superposition of the spectra of the separate single systems. (2) This theorem is then assumed valid for molecular systems which are coupled only by their surface conditions. (3) This assumption is then tested by working out the case of two coupled chains of quasi-elastic particles, the result being in satisfactory accordance with (2). (4) The introduction of individual frequencies for two coupled systems is in contradiction with (2). (5) The thermodynamic function is also applied to the problem. [See Abstract No. 918 (1914).]

E. H. B.

1566. *Sensitiveness of the Ear to Musical Sounds.* Marage. (Comptes Rendus, 158, pp. 1488-1440, May 18, 1914.)—The author has previously shown (1905), that for each vowel a certain minimum energy is necessary for audibility at a given pitch. It was then desirable to ascertain if a similar relation held good for certain musical sounds accompanied by a number of harmonics. For this a test was made by allowing a class of 800 students at the Sorbonne to hear compositions of the sixteenth and seventeenth centuries on various instruments of that epoch, harpsicord, clavicord, lute, and viol. About half of these auditors gave a good account of what they had heard and the results show distinct sensitiveness to certain musical sounds.

E. H. B.

1567. *Æolian Tones.* F. Krüger and A. Lauth. (Ann. d. Physik. 44, No. 5, pp. 801-812, June 19, 1914.)—Discusses the theory of æolian tones on the basis of vortex motions and confirms its conclusions by comparison with the well-known experimental results of Strouhal. [See Abstracts Nos. 294 (1912) and 1116 (1918).]

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1568. *Theory of Faraday-effect.* P. Selényi. (Phys. Zeitschr. 15. pp. 284-286, March 1, 1914.)—Describes a mechanical model for the qualitative and quantitative illustration of the Faraday effect. It consists of a weighted string along which a circular transverse wave is propagated. E. E. F.

1569. *Evaporation of Mercury Droplets suspended in a Gas.* A. Schidlöf and A. Karpowicz. (Comptes Rendus, 158. pp. 1992-1994, June 29, 1914.)—The authors have previously experienced difficulty with experiments as to the value of the electron charge from the motion of mercury droplets between the plates of a condenser, in that the speeds of these drops become less with increase of time under given fields. They have now tried nitrogen as well as air between the condenser plates, and extended the time to over an hour. The speed-time graphs slope down in the same way for each gas, the speeds becoming less and less as time goes on. The reductions in an hour's time are to about a half in the case of air and to about one-fifth for nitrogen. It is also noticed that the droplets become more difficult to see as the experiments proceed. The conclusion adopted is that the droplets of mercury suffer evaporation under the action of the light. [See Abstract No. 848 (1918).] E. H. B.

1570. *Electric Conduction in Metals.* F. Skaupy. (Deutsch. Phys. Gesell., Verh. 18. 10. p. 494, May 30, 1914.)—Points out that a slip has been discovered in the previous work of the author under the above title [see Abstract No. 961 (1914)]. The full explanation and correction are reserved for a later communication. E. H. B.

1571. *Electric Charges less than that on the Electron.* F. Ehrenhaft. (Ann. d. Physik, 44. No. 5. pp. 657-700, June 19, 1914.)—A very full and elaborate account of this research which has previously been sketched in outline. [See Abstracts Nos. 282, 508, 947 (1911); 509 and 1800 (1914).] E. H. B.

1572. *Principle of Least Work in the Electrodynamics of Moving Bodies.* J. Ishiwara. (Ann. d. Physik, 42. No. 5. pp. 986-1000, Dec. 2, 1918.)—A discussion of the subject with special reference to the work of Henshke [Abstract No. 1252 (1918)].

1573. *Electrification Produced during the Raising of a Cloud of Dust.* W. A. D. Rudge. (Roy. Soc., Proc. Ser. A. 90. pp. 256-272, May 28, 1914.)—A continuation of previous work [see Abstracts Nos. 1182 (1913) and 386 (1914)]. The results of the present experiments confirm generally those given in the former papers. The raising of a cloud of dust is accompanied by the production of large charges of electricity. Some of the dust particles have positive charges, and others negative. Either one set of charged particles settles rapidly, leaving the other set in the air, or else a charge is given to the air itself. The experiments do not show which of these views is correct. The charge is retained by the air for some considerable time. The

sign of the charge remaining in the air depends upon the nature of the material used. "Acidic" bodies, such as finely-divided silica or molybdic acid, give to the air a negative charge, whilst "basic" bodies, such as lead oxide, or organic dusts, such as flour or coal, give a positive charge. The total electrification of dust and air is zero. The friction between particles of similar material apparently produces sufficient electrification to account for the charges observed. An unweighable amount of dust can produce an easily measurable charge.

A. W.

DISCHARGE AND OSCILLATIONS.

1574. *Photoelectric Effect of Carbon as Influenced by its Absorbed Gases.* O. Stuhlmann and R. Piersol. (Nature, 98. p. 454, July 2, 1914.)—The existing contradictory results on the photoelectric effect of carbon can be explained by means of the quantity and quality of the gases absorbed by the carbon. The influences of ammonia, hydrogen, air, and carbon dioxide are investigated. The most consistent results are obtained from carbonised bamboo and hydrogen. Saturation curves show ammonia to be the most active, and carbon dioxide the least. Distribution-of-velocity curves are obtained for bamboo and hydrogen. The maximum initial velocity is found to be independent of the quantity of hydrogen absorbed, while the maximum current is proportional to the quantity of gas absorbed.

A. E. G.

1575. *Photoelectric Currents in Gases.* A. Partzsch. (Ann. d. Physik, 44. No. 4. pp. 556–584, June 4, 1914.)—The results of a number of measurements of the current through various gases obtained from a Pt-plate illuminated with ultra-violet light are given in which the field strength and pressure are varied between wide limits. These measurements confirm an early observation of Stoletow's that for a given gas the current is constant if the ratio of field strength (X) to pressure (p) remains constant provided no ionisation by collision is present. The curve connecting the current i with the ratio X/p for air and hydrogen was found to be of the form $i = i_1(X/p)^{0.40}$, a form which the author shows to be such as would be expected from the mechanism of the conduction. Ohm's law as found by Stoletow is obeyed for low values of X/p . The author is, however, chiefly concerned with a comparison of the effects in various gases. A number of tables and curves are given for measurements at atmospheric pressure in air (damp and dry), CO_2 , H, and O under various conditions as to the surface of the metal and the order in which the gases are used. In this way it was possible to eliminate to a certain extent the direct effect of the gas upon the photoelectric properties of the metal and thus to study the currents through the gases independently. The following results are obtained :—The current in CO_2 is greater than that in air for the higher values of the field, but smaller for the lower values ; it is continuously greater (a) in air than in hydrogen, (b) in damp air than in dry, and (c) in oxygen than in air. The ratio is a maximum in most cases for the intermediate field strengths. These results are discussed first from the point of view of the theories of conduction given by J. J. Thomson ["Conduction in Gases"] and by Bloch [see Abstract No. 959 (1910)]. These theories are in agreement with the Stoletow law but do not agree with the author's observations on the relative effects in different gases or with the comparison between the currents in a gas and a vacuum. The author advances the view that the number of ions which diffuse back, and therefore the current, depending as it does upon whether the ions exist as free electrons or as

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complex ions, depends on the electron-affinity of the gases. This explains qualitatively the order of the results, but needs to be tested further by experiments on electro-positive gases such as He, A, and N. F. J. H.

1576. Energy of Photo-electrons from Sodium and Potassium as a Function of the Frequency of the Incident Light. W. H. Kadesch. (Phys. Rev. 8. Ser. 2. pp. 867-874, May, 1914.)—The energy of photo-electrons as a function of the frequency of the incident light has been studied in numerous researches, but with little concordance of results. Ladenburg concludes that the emission velocity varies directly as the frequency. Joffé showed, however, that Ladenburg's observations were in quite as good agreement with the view that not the velocity of electrons but their energy, varies as the frequency. Kunz at first found a linear relation between energy and wavelength. Later observations led him to develop a theory according to which the velocity varies as the frequency. Wright found a maximum in the energy curve and this was taken as a confirmation of the view that the photoelectric effect is a resonance phenomenon. The same conclusion had been reached by Lenard and by Ladenburg and Markau. Hughes found a linear relation between energy and frequency, as did also Richardson and Compton. Cornelius obtained results which were taken to support the theory of Kunz. Compton, however, showed that according to Cornelius' data the energy is more nearly proportional to the cube of the frequency than to the square. It was with the hope of eliminating some of the difficulties and errors that beset investigators in this field that the present research was undertaken. The chief sources of uncertainty in photoelectric work have been the following: (1) The illuminated surfaces have usually been of metals sensitive to only a short range of frequencies. (2) Surface conditions have not been controlled, so that there was no assurance of uniformity throughout a set of observations. (3) There has been in some cases much trouble with reflected light. In order, as far as possible, to obviate these difficulties, surfaces of the strongly electro-positive metals, sodium and potassium, are illuminated, these being sensitive to long waves as well as short, a device being employed for exposing a fresh surface very readily, and as often as desired. The apparatus used is described in detail. The results of the investigation are in agreement with those of Hughes and of Richardson and Compton. They may be expressed by an equation of the form $V = K_n - V_0$ in which V is the p.d. in volts between the electrode and the adjacent parts of the tube, just sufficient to prevent a deflection of the electrometer, n is the frequency of the incident light, and K and V_0 are constants. According to Einstein's theory the relation between energy and frequency should be represented by the equation $V_e = R\beta n/N - P$ in which e is the elementary electrical charge, $R\beta/N$ is Planck's constant equal to 6.55×10^{-27} , and P a constant representing the loss of energy suffered by an electron escaping from the metal. The observations on sodium gave a value for K equal to 8.87×10^{-15} , those on potassium 8.88×10^{-15} . Writing the equation in the form given by Einstein, and substituting for e , 4.772×10^{-10} , the slope for sodium becomes 6.16×10^{-27} , that for potassium 6.09×10^{-27} . It is shown that the total observational error would not account for a difference as large as that between the slopes of the experimental curves and that of Einstein's formula. A. E. G.

1577. Effect of Space Charge and Residual Gases on Thermionic Currents in High Vacuum. J. E. Lilienfeld. (Phys. Rev. 8. Ser. 2. pp. 864-866, May, 1914.)—A reply to Langmuir's paper [see Abstract No. 725 (1914)].

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1578. Powerful Röntgen Tube with a Pure Electron Discharge. J. E. Lilienfeld. (Phys. Rev. 8. Ser. 2. p. 866, May, 1914.)—A reply to Coolidge's paper [see Abstract No. 564 (1914)].

1579. Experiment Illustrating Spatial Density of Electrons. F. L. Hopwood. (Electrician, 73. p. 700, July 81, 1914.)—The experiment is the outcome of one previously described by A. S. Eve and by the author [Abstract No. 942 (1914)]. If the temperature of the lamp filament is raised by over-running the lamp a negatively charged rod no longer causes a displacement of the filament. That this is due to the spatial density of the electrons having the effect of diminishing the possible electron current [see Abstract No. 725 (1914)] is shown by means of a lamp containing two separate filaments. When one filament only is heated the effect is shown, but when the electron density is increased by heating the second filament the effect no longer exists. By heating one filament only and using the lamp as a Fleming valve the effect was shown not to be due to the production of positive electricity. F. J. H.

1580. Electrification by Röntgen Rays. C. G. Bedreag. (Comptes Rendus, 159. pp. 169–171, July 8, 1914.)—The author has previously pointed out that the charge obtained on a metallic electrode exposed to Röntgen radiation changes, with variation of pressure around the electrode, from a negative value at high pressures to a positive value in a vacuum [see Abstract No. 1706 (1913)]. If the negative charge were due to a difference in mobility of positive and negative ions, then in CO_2 the charge should be very much diminished owing to equal mobility of the ions. This is not found to be the case. When the distance r of the electrode from the anterior wall is varied, the charge Q may be represented by $Q = Q_0 e^{-ar} + K/d^2 \pm hE$; Q_0 being the cathodic emission from the anterior wall, a the coefficient of diffusion, K the positive effect upon the same electrode, d the distance of the electrode from the antikathode of the Röntgen tube, and $\pm hE$ an effect due to chemical variation of the surface of the electrode. The influence of the intensity of the radiation, and homogeneous Röntgen radiations are also considered.

A. E. G.

1581. Nature and Velocity of Migration of the Positive Ions in Flames. A. H. Saxer. (Phys. Rev. 8. Ser. 2. pp. 825–888, May, 1914.)—Measurements of the velocity of migration in an electric field of the positive ions introduced into a colourless Bunsen flame by the volatilisation of an alkali salt in it have given widely divergent results. Thus, Lenard obtained a value of 0.08 cm. per sec. for the positive ions produced by lithium, whereas Lusby arrived at the velocity 850 cm. per sec. for the positive ions of all alkali salts at about 1950° abs. The author has therefore constructed an apparatus, with which he has made a number of measurements with various salts of the alkali metals. The results show that the max. velocity of the positive ions of the colourless Bunsen flame is 1.8 cm. per sec. when measured in the flame itself where the temperature is 1250°C. , and 2.5 cm. per sec. when measured in hot air at 475°C. ; these ions have their velocities reduced in the presence of alkali salt vapours. The velocity of the positive ions of the various alkali salt vapours is less than the velocity of the positive ions of the pure flame. These ions are the nuclei of large molecular aggregates and they carry with them the spectrum of the metal used in their production. T. H. P.

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1582. *Magnetic Rays in Various Gases and Gas Mixtures. II. A. Righi.* (N. Cimento, 7. Ser. 6. pp. 208-250, April, 1914. Phys. Zeitschr. 15. pp. 558-568, June 1, 1914.)—A continuation of previous work [Abstract No. 529 (1914) and Phys. Zeitschr. 15. p. 528, 1914]. The virtual anode effect is considered in the following gases: Hydrogen, oxygen, CO₂, CO, nitrogen, ether vapour, chloroform vapour, and mixtures of pairs of these gases. The results are described in detail with the help of diagrams, and in opposition to the views of More and Mauchly [Abstract No. 1995 (1918)] the author considers that his neutral pair theory gives the simplest explanation of the phenomena. [See also Abstract No. 1471 (1918).] A. W.

1583. *Ionisation by Collision in Mercury Vapour. J. Franck and G. Hertz.* (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 457-467, May 30, 1914.) In a previous paper [Abstract No. 659 (1918)] the authors investigated the ionisation potentials for various gases, and showed that it had a definite magnitude for each gas. Measurements were made with He, Ne, Ar, H, O, and N. In the present paper the authors deal with collisions between electrons and molecules of mercury vapour and the ionisation potential for this vapour. A new method of measuring the ionisation potential was employed, and is described in detail. It is shown that the electrons in mercury vapour undergo elastic collisions with the molecules up to a critical velocity. A method is described whereby this critical velocity may be measured accurately to a tenth of a volt. In the case of mercury vapour the critical velocity is equal to that which the electrons possess with a fall of potential of 4.9 volts. It is shown that the energy of a 4.9-volt ray is very nearly the same as the energy-quantum of the mercury resonance line $\lambda 2586$. The results are discussed, and it appears that in the giving-up of energy of the 4.9-volt ray to the mercury molecule a part of the impact leads to ionisation, from which it is deduced that 4.9 volts is the ionisation potential of mercury vapour. Another part apparently gives rise to emission of light, presumably the line of wave-length 2586. Further research in this direction is in progress. A. W.

1584. *Excitation of Mercury Resonance Line $\lambda 2586$ by Electron Collisions. J. Franck and G. Hertz.* (Deutsch. Phys. Gesell., Verh. 16. 11. pp. 512-517, June 15, 1914.)—A continuation of previous work [see preceding Abstract]. Using a Pt-wire heated by an electric current as a source of electrons in a quartz chamber containing mercury vapour, the authors were able to show that the mercury line $\lambda 2586$ was excited by the electron collisions, under the conditions obtaining in their experiments. From the research on the collisions between electrons and mercury atoms the following conclusions are drawn:—(i) The electrons are reflected by the mercury atoms without loss of energy, so long as their kinetic energy is smaller than the amount $h\nu$, where ν is the frequency of the corresponding resonance line. (ii) As soon as the kinetic energy of an electron has reached the value $h\nu$ this energy-quantum is at one of the next collisions of the electron transferred to the atom spectrum of frequency ν . (iii) The transferred energy is partly used in producing ionisation and partly results in the emission of light of frequency ν . (iv) The value of h given by the present researches is 6.59×10^{-27} erg sec., with a possible error of 2 %. A. W.

1585. *Velocities of Photo-electrons. G. A. Dima.* (Comptes Rendus, 158. pp. 1578-1575, June 2, 1914.)—The measurements were made by the ordinary VOL. XVII.—A.—1914.

method of determining the potential necessary to stop the photo-electrons, contact difference of potential being measured by a special arrangement and allowed for. The results so far obtained agree closely with those of Compton [Abstract No. 1465 (1918)]. E. M.

1586. Production of Light by Kathode Rays in Hydrogen. J. Holtsmark. (Phys. Zeitschr. 15. pp. 605-608, June 15, 1914.)—Kathode rays from a lime kathode in hydrogen are sent through a slit into an enclosed cylinder so as to free them from the influence of an electric field. The light produced is split up into its spectrum and photographed, the relative intensities of the lines H_{β} and H_{γ} being compared in the manner described by Kock [Abstract No. 878 (1910)]. With a possible error of 20 % the relative intensity is independent of the kathode-ray velocity over a voltage range of from 20 to 1700 volts. It is, however, dependent upon the gas pressure, the lines towards the red end of the spectrum becoming relatively stronger than those towards the violet end with increasing pressure. No change in the relative intensity with current density was observed over the range of 0.5 to 82 milliamps., although the pressure effect appears to be different for different currents. The effects observed are similar to those described by Vegard [Abstracts Nos. 113, 1183, 1478 (1913)] for the negative glow and for the light produced by canal rays. F. J. H.

1587. Limiting Potentials with Cylindrical Electrodes. W. Schottky. (Deutsch Phys. Gesell., Verh. 16. 10. pp. 490-494, May 30, 1914.)—When electrons are emitted from an earthed hot wire, the receiving electrode charges itself to a limiting positive potential. In the case of a hot wire stretched along the axis of a cylinder, the author shows how to calculate limits within which the max. potential must lie, the lower limit being calculated on the assumption that no electrons are reflected from the cylinder, the upper limit on the assumption that the density of the free charge between the wire and cylinder vanishes. J. R.

1588. Current between an Incandescent Filament and Coaxial Cylinder. W. Schottky. (Phys. Zeitschr. 15. pp. 624-630, June 15, 1914.)—The relationship $\phi = (9/2\sqrt{2}\gamma)^{1/2} J$ has been obtained by Langmuir [Ibid. p. 848, also p. 516 (1914)], and independently by the author [see preceding Abstract] for the p.d. ϕ needed to send an electron current J from a thin incandescent filament per unit length to a concentric cylinder of radius R , γ being the ratio of the charge to the mass of the electron. A careful mathematical investigation shows that certain corrections arising from the spatial density of the electrons are needed for the lower potentials. Limiting values for these corrections are given, from which, conditions favourable to the validity of the relationship are deduced. Measurements with tungsten, tantalum, and carbon filaments in cylinders of different radii show the approximate validity of the expression for potentials below 11 volts, the departures having the expected characteristics. In the case of the carbon filament it is very difficult to obtain good curves, a fact which is probably explained by the emission of positive ions. The action of the space charge is increased by the presence of hydrogen below the sparking potential, but above this potential the effect is more or less nullified. [See also next Abstract.] F. J. H.

1589. Emission of Electrons from an Incandescent Filament under the action of a Retarding Potential. W. Schottky. (Ann. d. Physik, 44. No. 7. pp. 1011-VOL. XVII.—A.—1914.

1082, July 17, 1914.)—The paper is both a theoretical and an experimental investigation into the electron current between an incandescent filament and a coaxial cylinder in an extreme vacuum under the action of a retarding potential. The theoretical calculation is made on the assumption that the electrons are emitted from the filament with velocities distributed according to the Maxwell law. With the stronger electron currents, *i.e.* with the smaller retarding potentials, a diminution of the current arising from the retarding forces called into play by reason of the spatial density of the electrons is taken into consideration, expressions being given for obtaining superior and inferior limits to the value of the potential at which the action begins. The experimental curves obtained for carbon and tungsten filaments agree well in most cases with the theoretical curves for values of the current for which the spatial density produces no effect, thus verifying the application of the Maxwell law. There are, however, in the region of the higher electron velocities certain departures from the theoretical values which lie outside the limits of experimental error. In addition to the above a contact p.d. between the hot wire and the cylinder is considered, and shown to exist experimentally. By means of experiments with cylinders of different materials the contact p.d.'s between these at ordinary temperatures could be obtained. These agree well with well-known measurements in ionised air.

F. J. H.

1590. *Electrodeless Ring Discharge in Mercury Vapour.* J. v. Kowalski. (Phys. Zeitschr. 15. pp. 249–250, March 1, 1914.)—A quartz bulb filled with mercury vapour shows in an electric alternating field a brilliant white glow at 60° and an emerald green glow at 140°. This confirms the result of Wachsmuth and Winawer [Abstract No. 186 (1914)] that mercury vapour, like other gases, has two ionisation energies. The two forms of glow can be exhibited by simply heating and shaking the bulb.

E. E. F.

1591. *Theory of Glow Discharge.* R. Holm. (Phys. Zeitschr. 15. pp. 241–249, March 1, and pp. 289–298, March 15, 1914.)—Assumes, with J. Franck, that electrons suffer inelastic reflections from molecules, the loss being the greater the slower the electrons. The absorption of electrons by neutral molecules is much more frequent than their recombination. A portion of the energy of impact is liberated in the form of a radiation which allows of an increase of the ionisation by collision. These hypotheses are worked out to what is claimed to be a satisfactory theory of the stratified and unstratified glow discharge.

E. E. F.

1592. *Discharges in Geissler Tubes and Spectral Effects Produced.* M. Millochau. (Journ. de Physique, 4. Ser. 5. pp. 206–221, March, 1914. Paper read before the Soc. franç. de Physique.)—A comparative study of the discharge in a Geissler tube and the corresponding spectrum obtained. The method consists in photographing both the discharge (by a rotating film) and the spectrum produced by it (by a spectrograph) at the same time. The discharge is usually produced by a condenser, capable of being charged to 15,000 volts, oscillatory discharges being obtained by inserting a self-induction in the condenser circuit. The author classifies the discharges, both continuous and oscillatory, according to their duration and from the point of view of the spectral effects obtained. In such tubes the discharge occurs if the potential rises above a superior limit V_s , and ceases when the potential is lowered past an inferior limit V_i . The results obtained are explained on the

supposition that the spectrum tube possesses a large capacity in virtue of the discharge, and it is shown that when the discharge is oscillatory the expenditure of energy in the tube is such that the charge of the system is lowered by a constant quantity each oscillation whatever be the period. When the discharge is continuous the circuit acts like a metallic circuit of which the resistance is equal to that employed multiplied by a constant coefficient. Thus a spectrum tube is characterised by five constants: V_0 , V_a , the apparent capacity, the coefficient of resistance (ρ), and the fall in potential per oscillation of the charge passing. The mean energy expended per unit time can be calculated, giving, for the slow discharge, $(\rho - 1) C(V^2 - V_a^2)/t$, where C is the capacity of the condenser used, V the initial potential, and t the duration of the discharge; and for the oscillatory discharge $C(V^2 - V_a^2)/nT$, where n is the total number of oscillations of period T . For a tube containing hydrogen it is found that for the continuous discharge, the mean energy utilised per sec. is between 800 and 8600 joules, when the line spectrum (stellar series) with sharp lines is observed. With the oscillatory discharge, duration $1/10$ to $1/100$ sec., the value is between 8000 and 82,000 joules, and the lines are slightly diffuse, becoming more so as the energy expended per sec. increases. When the value is greater than 8.2×10^{14} joules, the duration of the discharge being less than 0.8×10^{-8} sec., the spectrum is continuous with maxima in the places of the lines of the stellar series.

The author concludes that the spectrum given by a tube depends uniquely upon the quantity of energy transformed in it per sec. T. H.

1593. *Electric Brush Discharge in Weak Acids and Solutions.* H. Smith. (Phil. Mag. 27. pp. 801-828, May, 1914.)—The changes which occur in the spectra of the electric brush discharge in solutions under varying electrical conditions have been investigated in a previous paper [Abstract No. 1881 (1913)]. In the experiments there discussed the brush in all cases was alternating, and observations were confined to the visible region ($\lambda 6700$ to $\lambda 4200$). The present research was undertaken to extend the observations into the ultra-violet region and to investigate the differences which may occur between the positive and negative brush. A large number of solutions were examined but only the uncondensed brush was used. The results of the investigation may be summarised as follows:—The series and secondary spectrum of hydrogen are a great deal brighter in distilled water than in solutions for the same current value. In distilled water they are stronger in the negative brush than in the positive for the same current. When the potential drop through the brush is the same in each case, the spectra are strongest in the positive brush. In solutions, the intensity of the spectra relative to the rest of the brush spectrum (water-vapour bands, Pt, and oxygen lines, etc.) is considerably diminished. Neither the nature of the solution nor the sign of the brush has any perceptible effect. There is no certain indication that electrolysis plays any part in the appearance of the spectra. The spectrum of the metallic lines of the solute appears in the negative brush in solutions. For constant current the spectrum grows in intensity with the concentration till a certain value of the concentration is reached, when no further increase occurs. The spectrum appears in the case of the positive brush in the strongest solutions, and then only very faintly. The behaviour of the spectrum in all cases can readily be explained from the point of view of electrolysis. The elementary line-spectrum of oxygen appears in distilled water in both the positive and negative brush. In dilute acids solutions of Mg and Zn sulphates, and in tap water, it appears in

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strength in the positive brush, but is generally absent or very weak in the negative. In solutions of the salts of Li, Na, and K, its appearance in the positive brush is the same as for other solutions; in the negative brush the spectrum appears with the metallic lines of the salt, increases in intensity with them, and reaches its maximum with the same concentration of solution. The negative bands of nitrogen behave in the same manner. In the negative brush both the positive and negative bands appear in general remote from the point, while the oxygen lines are always produced close to the point. The arc spectrum of Pt appears in the negative uncondensed brush. In the condensed brush the spark lines appear. When copper wire is used in the point electrode the copper lines appear in each brush but are stronger in the negative. The water-vapour bands appear in each brush equally well.

A. W.

1594. *Diffraction of Electric Waves at a Dielectric Cylinder.* Kobayashi-Iwao. (Ann. d. Physik. 48. No. 6. pp. 861-898, March 20, 1914.)—The experiments of Schaefer and Grossmann [Abstract No. 720 (1910)] on dielectric currents and resonance yielded results which did not quite agree with theory. The mathematical theory is now given more fully, and is shown to be in complete agreement with experiment.

E. E. F.

1595. *Discharge of Electricity from Cylinders and Points.* J. S. Townsend and P. J. Edmunds. (Phil. Mag. 27. pp. 789-801, May, 1914.)—Watson has investigated discharges through air at pressures varying from 1 atmo. to 0.5 atmo. and with wires between 12.8 and 0.7 mm. diam. Townsend [Abstract No. 1382 (1918)] found that an explanation of Watson's results could be obtained on the hypothesis that the ionisation was due to collision, as had previously been found for discharges between parallel plates at low pressures. The present investigation was undertaken to test the theory over a range of pressures of air from 1 mm. to 760 mm. with wires of various diameters. Two cylinders of brass were used; a large one, internal diam. 14.9 cm. and effective length 66 cm., and a smaller one, internal diam. 8.96 cm. and length 44 cm. The ends were closed with thick glass discs through the centres of which wires of various diameters could be inserted and fixed. For details of apparatus and method of operation see original paper. On the hypothesis that the sparking potential is determined by ionisation by collision, it is found that the sparking potential V for a pair of cylinders of radii a and A when the pressure is p is the same as that for a pair of cylinders of radii ka and kA when the pressure is p/k . Hence, if X_1 is the electric intensity at the surface of the inner cylinder, aX_1 is constant when ap is constant for pairs of cylinders which are geometrically similar. The condition that X_1 should be independent of the radius of the outer cylinder is that X_0/p should be less than 40, X_0 being the intensity at the outer cylinder. This condition was satisfied in the experiments, and so theory gives the simple result that aX_1 should be the same for all wires for the same value of ap . To test this a curve, giving the relation between the sparking potential and the pressure, was drawn for each wire; these curves were found to be quite regular. Watson's results may be represented in a similar manner. In general a marked difference was found between the sparking potentials when the wire was charged positively and when the wire was charged negatively. At the smaller values of ap the sparking potential was found to be lower when the wire was negative than when it was positive, but with values of ap from about 5 to 20, a lower potential was required to produce a positive discharge.

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Experiments were also made with blunt points, the discharge passing from these to planes. Observations were also made of the relation of the rise in potential to the current, and also of the effect of moisture. It was found that the increase of potential required to maintain a given negative discharge depended on the dryness of the air. Theory shows that the potential v required to maintain a small current I is given by the formula—

$$v(v - V) = [IA^2 \log A/a]/2k,$$

k being the velocity of the ions under unit electric force, and V the sparking potential. The potentials v required to maintain small currents were quite consistent with this expression, but no very accurate determinations of k have yet been deduced from the observations. It was found that dI/dv was smaller for positive than for negative discharges. Also when the air was damp, dI/dv for negative discharges diminished, showing that the negative ions, in the space in which X/p is small, are affected by the moisture. But in the space near the inner cylinder where X/p is large the negative ions are not affected by the moisture, since the sparking potentials are the same for moist and dry gases. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1596. Positive and Negative Temperature Coefficient of the Resistance of Non-electrolytic Conductors. F. Streintz. (Ann. d. Physik. 44. No. 4. pp. 545–555, June 4, 1914.)—The author and also other investigators have usually found that the electrical resistances of compressed, powdered metallic oxides, sulphides, etc., diminish with rise of temperature. This may, however, not be actually a property of the material itself, but may be due to the over-compensation of the positive resistance coefficient by the negative coefficient of the transition resistance set up at the surface of separation of the conductor and the circuit. That non-electrolytic conductors, like compact metals, have positive temperature-coefficients of resistance is rendered probable by the results of experiments with pressed platinum black, which demonstrate the great influence exerted by the transition resistance of a powder on the apparent temperature-coefficient. T. H. P.

1597. Resistance of Crystallised Antimony. W. J. de Haas. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 1110–1128, May 29, 1914.)—Thin plates of antimony were split off along cleavage planes, immersed in shellac, and polished into small rods. The resistance of such rods at temperatures (θ) down to that of liquid air could be expressed by means of the formula: $R = R_0(1 + a\theta + \beta\theta^2)$. The resistance of antimony was also measured at 18° in a field of 28 kilogauss with various angles between the direction of the field and the principal axis of the crystal. The ratio of the resistance in the field to that with no field can be expressed for all temperatures by a formula of the form: $R'/R = a - b \sin c(d - H)$, where a , b , and d are constants. It is concluded that the field has a directing influence on the diamagnetic metal molecules, and that there exists a connection between crystal system, resistance change, and diamagnetic susceptibility. [See also Abstracts Nos. 74 (1900) and 115 (1907).] G. E. A.

1598. Electric Resistance of Crystals and Residual Electromotive Forces. P. Collet. (Comptes Rendus, 158. pp. 1994–1997, June 29, 1914.)—An experimental research from which the following conclusions are drawn:—(1) The VOL. XVII.—A.—1914.

contact is of preponderating importance, in finding the absolute value of the resistance. If the contact is satisfactory the phenomena are much simpler and more regular. (2) There is a residual e.m.f. of sense opposite to the current through the crystal, and the polarisation effect may be referred to thermoelectric phenomena. E. H. B.

1599. *The Action of Light on Selenium.* W. S. G ripenberg. (Phys. Zeitschr. 15. p. 462, May 1, 1914.)—An account of experiments which indicate that the action of light on selenium extends deeply into the interior of the substance. J. J. S.

1600. *Contact Potential in Vacuum.* W. Schottky. (Deutsch. Phys. Gesell., Verh. 16. 10. pp. 482–485, May 80, 1914.)—Describes by a diagram a method for the exact determination of contact p.d. in a vacuum and discusses its difficulties. E. H. B.

1601. *Pyro-electricity.* S. Boguslawski. (Phys. Zeitschr. 15. pp. 288–289, March 15, 1914.)—To explain deviations from the Clausius-Mosotti formula for dielectrics, the author gives up the conception of quasi-elastic displacements, and represents the work of displacement by a series of terms $ax^2 + bx^3 + cx^4$, where x is the displacement, and a is always positive. The fourth-power term produces a diminution of the quantity $(\epsilon - 1)/\rho(\epsilon + 2)$ with increasing temperature if $c > 0$, or an increase if $c < 0$. It produces a very small deviation from the proportionality of displacement and field intensity. The cubic term produces a polar pyro-electric effect, and also a polarity of dielectric properties, which, however, is excessively small. E. E. F.

1602. *Thermo-junction of Carbon and Graphite.* C. C. Bidwell. (Phys. Rev. 8. Ser. 2. pp. 450–452, June, 1914.)—A thermo-junction of carbon and graphite designed to measure the temperature of molten metals beyond the reach of the Pt and Pt-Rh thermocouple is described [see Abstract No. 1568 (1914)]. Rods of carbon and graphite 80 cm. long and 2 mm. diam. have pointed ends which are brought close together in the molten metal. The cold ends are fitted to heavier rods 50 cm. long which are connected by copper leads to the galvanometer. The e.m.f. of the couple is large, being approx. 0.02 microvolt per deg. and is nearly linear up to 2000° C. It is, however, somewhat erratic unless the rods are previously heated up to 2000° C. at which temperature all impurities affecting the e.m.f. are given off. When the couple is used in air the rods gradually oxidise just above the surface of the molten metal, so that new points have occasionally to be made. A disadvantage of the couple is that when this occurs owing to the heterogeneity of the materials a new calibration is needed. Curves are given showing a series of calibrations after re-pointing. If rods of greater purity protected from oxidation were used a serviceable instrument might be made. F. J. H.

1603. *E.M.F. between Portions of the Same Metal at Different Temperatures.* H. Hörig. (Phys. Zeitschr. 15. pp. 888–898, April 15, 1914.)—A theoretical discussion of the author's previous experiments on the e.m.f. due to temperature gradient in a metal [see Abstract No. 1116 (1914)]. A more accurate measurement of this effect may lead to a decision as to the admissibility of certain hypotheses with regard to the transfer of electricity and the nature of the Thomson-effect. J. J. S.

1604. *Thermoelectric Properties of Selenium - Antimony Mixtures.* H. Pelabon. (Comptes Rendus, 158, pp. 1669-1671, June 8, 1914.)—Comparison of the thermoelectric powers of couples consisting of Pt and mixtures of Se and Sb confirm the existence of only one compound between these two elements, Sb_2Se_3 , the thermoelectric power of mixtures containing less Se than this being little different from that of pure Sb, but suddenly increasing more than ten times as the composition required by Sb_2Se_3 is reached. With larger proportions of Se, the thermoelectric power remains about that of Sb_2Se_3 . The latter reaches a maximum at a temperature of about 700°C ., that of the cold junction being kept at 11°C . [See also Abstract No. 1401 (1911).] W. H. St.

1605. *Thermoelectric Power of Tin Selenides.* H. Pelabon. (Comptes Rendus, 158, pp. 1897-1900, June 22, 1914.)—The existence of the two compounds $SnSe$ and $SnSe_2$ is confirmed by determination of the thermoelectric powers of couples consisting of Pt and alloys of Sn and Se. Both compounds have a high thermoelectric power, increasing rapidly with rise in temperature of the hot junction, but being opposite in sign, the current passing from $SnSe_2$ to Pt through the hot junction. They are good conductors, melt at relatively high temperatures, and are very suitable for the production of sensitive thermopiles. W. H. St.

1606. *The Actino-dielectric Effect.* F. Schmidt. (Ann. d. Physik, 44, No. 8, pp. 477-496, May 26, 1914. Abstract of Part 2 of Dissertation, Heidelberg.)—[See Abstracts Nos. 878 (1909) and 726 (1905).] The actino-dielectric effect on a thick layer of a Ca-Bi phosphorus was first measured for different wave-lengths of light. A maximum of the effect was found in the red, and two minima at 820 and $420\ \mu\mu$. These minima occur for the wave-lengths at which the natural emission of light from the phosphorus is a maximum. Hence the conclusion is drawn that the correct relation between the actino-dielectric effect and wave-length of light has not been obtained, for these minima are due to the light being absorbed in the upper layers of the phosphorus, thus leaving the lower layers still non-conducting. To get a correct relation, thin transparent layers and not thick opaque layers must be used. With such thin layers one maximum was found at $580\ \mu\mu$ and one minimum at $480\ \mu\mu$. The use of thin films also gives some idea as to the nature of the conduction produced in the phosphorus by light. A thick opaque layer cannot be made wholly conducting, and the only effect that can be observed with such is of the nature of a dielectric polarisation. With thin transparent layers it was shown that the conduction is of the nature of an electrolytic effect. Apparently the molecules of the phosphorus are decomposed by light and the ions thus formed account for the conduction. When the light is removed the ions recombine and soon the material becomes a dielectric again. J. R.

1607. *Thermoelectrics of Strained Wires.* J. McWhan. (Roy. Soc. Edinburgh, Proc. 84, pp. 64-68, 1918-1914.)—It has been shown that curves of thermoelectric force are, for many metals, parabolas whose axes are inclined at very small angles to the e.m.f.-axis [see Abstract No. 870 (1911)]. The author describes experiments made on a thermo-couple consisting of two pure nickel wires, one unstretched and the other subjected to any desired tension, while an approximately constant temperature-difference of $75\ \text{deg. C}$. was maintained between the two junctions. The curve connecting tension

with the e.m.f. developed was found to be parabolic, with the axis inclined at an angle of nearly 4° with the e.m.f.-axis, the maximum point observed being 17.868×10^{-6} volt at a tension of .11 kg. Previous similar experiments on non-magnetic metals nearly all gave a straight line up to the point where overstrain set in. J. W. T. W.

1608. Silver and Iodine Voltameters. S. J. Bates and G. W. Vinal. (Amer. Chem. Soc., Journ. 86. pp. 916-987, May, 1914.)—An account of a careful comparison of the silver and iodine voltameters using them in series, so that the deposits of silver and iodine should be strictly comparable. The best procedure learned from previous investigations has been followed in each case. The results are as follows:—

1. Ratio of silver to iodine.....	0.85017
2. Electrochemical equivalent of iodine.....	1.81502
3. Value of the Faraday ($I = 126.92$)	96,515
4. Value of the Faraday ($Ag = 107.88$)	96,494
5. Value recommended for general use	96,500

The work was carried out at the Bureau of Standards.

F. E. S.

1609. The Silver Voltmeter. W. Jaeger and H. v. Steinwehr. (Elektrotechn. Zeitschr. 85. pp. 819-820, July 16, 1914. Communication from the Physikal. Techn. Reichsanstalt.)—The advantages and disadvantages of the various forms of silver voltameters are briefly discussed, and some remarks made by Rosa, McDaniel, and Vinal [see preceding Abstract] are criticised. The authors believe the Kohlrausch form of voltmeter to be quite satisfactory, and that silk may be used to envelop the anode if necessary. The "volume effect" in voltmeters (i.e. the obtaining of a heavier deposit in a large voltmeter than in a smaller when an impure electrolyte is used) is doubted. F. E. S.

1610. Use of the Telephone as an Oscillograph. M. Siegbahn. (Phil. Mag. 27. pp. 909-914, May, 1914.)—It has frequently been proposed to use the telephone for the study of variable currents, as it would seem probable that the membrane will reproduce the variations of the current most accurately. It is known that even small peculiarities in a person's voice or speech can be recognised through telephonic transference. In a telephone under ordinary conditions the amplitude is of the dimension of 0.001 mm., and experience shows that speech transference is good only under these circumstances. Increasing the amplitude so that normal registering apparatus can give measurable deviations affects the accuracy of reproduction. Finally, good acoustical transference does not guarantee that the mechanical vibrations are identical with the electrical variations, nor do they even give a sufficiently good copy of them.

The author has previously described [Abstract No. 291 (1914)] a method for recording the vibrations of, say, 0.001 mm. with sufficient accuracy. Since the above-mentioned paper, the apparatus has been greatly improved. It consists of two coaxial microscopes, the first of which gives a greatly diminished ($\frac{1}{100}$) image of an illuminated slit 1 mm. broad. A sharp edge is mounted on the telephone diaphragm, which is placed in the image so as to screen off a great portion of the light ($\frac{1}{10}$). The rest passes through the other microscope and forms a magnified image on a photographic plate. While the membrane vibrates, the edge will screen off more or less of

the first image, which will cause a corresponding variation in the light-intensity of the image on the plate. On moving the plate perpendicular to the ray of light there will be sections with different brightness giving dark or bright lines on developing the plate. The darkness of the plate is a measure of the corresponding deviation of the membrane. In order to give a complete representation of the vibrations the darkness of the plate must be continually recorded. One of the methods used by the author was to allow the light to fall on a thermopile, the thermoelectric force being measured by a recording galvanometer. On moving the photographic plate slowly the galvanometer registers a curve where the deviations are approximately proportional to the degree of darkness of the different sections, that is, proportional to the deflections of the membrane. A number of oscillograms taken in this way are reproduced in the paper. The results show that the free vibrations of the membrane interfere greatly with the true reproduction, and rapidly varying effects cannot be examined in this way. The general conclusion reached is that the telephone cannot be used for oscillographic purposes. [See, however, Guyau, Abstract No. 1056 (1918).] H. H. H.

1611. *New Type of Thermogalvanometer.* F. W. Jordan. (Phys. Soc., Proc. 26, pp. 165-171; Discussion, p. 171, April, 1914.)—The puff of air from an orifice in an air chamber when the air within is suddenly heated is utilised in this instrument to deflect a small suspended vane. The current to be measured is made or broken through a heater of small thermal capacity in the air chamber and the outrush or inrush of air through the orifice delivers an impulse to the vane. The disturbing effects of extraneous heat and pulsations of external pressure are eliminated by a compensation method. In one instrument of this type the sensibility was 4 mm. per microwatt and the extremity of the throw of the vane was attained in 2 secs. AUTHOR.

1612. *Cascade Attachment for Graphite Furnace.* E. F. Northup. (Metallurgical and Chem. Engin. 12, pp. 805-806, May, 1914.)—Since everything tends to evaporate more rapidly under diminished pressure it appears to the author that it is wrong to use a vacuum furnace for the highest temperatures, and he has attempted to obtain a furnace in which high pressures and an inert atmosphere can be obtained by the use of large masses of graphite which are heated electrically. The device consists of a graphite resistor surrounded by a graphite tube, the whole being fixed in the chamber of the high-temperature graphite furnace previously described by the author [Ibid. pp. 81-88, Jan., 1914]. The outer furnace is first heated up to 1600° C. by a current of 5 kw. when the current is switched on to the resistor, the input being then raised to 8 or 9 kw. In this way a temperature of 8000° C. can easily be obtained inside the resistor, and since the temperature is produced in steps the arrangement has been called a "cascade" attachment. A graphite crucible can be placed inside the resistor for the fusion of such metals as tungsten, etc. F. C. A. H. L.

ALTERNATING CURRENTS AND MAGNETISM.

1613. *Permeability at Low Induction Densities.* A. F. Wagner. (Phys. Zeitschr. 15, pp. 587-591, June 1, 1914.)—An application of Burrows' compensated double-bar and yoke method in which two short bars are connected by yokes and a compensating magnetomotive force is applied to the yokes and connections to balance the reluctance of this part of the circuit.

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Measurements made with fields down to 0.005 gauss show that the method is applicable to low induction measurements, and B and H curves for four specimens show a uniform rise of B with H apparently from a zero at the origin. For the system of coils employed, the paper should be consulted. [See Abstract No. 525 (1911).] G. E. A.

1614. *Foucault Currents in Iron Anchor-ring.* A. Defretin. (Comptes Rendus, 158. pp. 1885-1887, June 22, 1914.)—When an anchor-ring is magnetised by means of an alternating current, its permeability being supposed constant, the mean induction for a given current is given by a complicated expression. From this expression two limiting laws are derived, viz. (1) the effective mean induction for a given current is inversely proportional to the square root of the frequency, if the latter is sufficiently great; (2) the effect of hysteresis is to cause a definite lag in the mean induction. These laws have been verified experimentally, for frequencies varying between 81 and 51. [See also Abstract No. 1289B (1918).] G. E. A.

1615. *Effect of a Magnetic Field on Metallic Resistance.* W. A. Jenkins. (Phil. Mag. 27. pp. 781-789, April, 1914.)—The metal examined was nickel which was used in the form of a short piece of very fine wire soldered at right angles to the ends of two thick copper wires and placed between the poles of an electromagnet. A Wheatstone bridge method was used for measuring the resistance and the temperatures of experiment were 18° and 98.5° C. Hysteresis curves for both longitudinal and transverse fields were obtained. The effect in a transverse field was found to consist of two parts: the first gives an increase and reaches a maximum; the second gives a decrease and does not reach a maximum. The longitudinal effect and the first part of the transverse effect possess similar characteristics. There is some relation between the dimensional change in a magnetic field and the resistance effect; one, however, is not the cause of the other, but both are probably due to an alteration of structure. The ordinary theory for the effect in a transverse field does not explain the results obtained. The effect is possibly due to a further structural change. J. J. S.

1616. *Properties of Electrolytic Iron Melted in vacuo.* T. D. Yensen. (University of Illinois, Bull. 11. No. 72. pp. 1-71, March 9, 1914.)—Describes experiments on the magnetic and mechanical properties of many different samples of iron, mostly electrolytic, containing various percentages of carbon from 0.0080 % to 0.181 %. To obtain the extremely low-carbon irons it was necessary to melt the iron *in vacuo* to avoid contamination, for, while it is found that a low-carbon iron melted *in vacuo* loses 50 to 90 % of its original carbon content, pure iron melted in an atmosphere of CO under atmospheric pressure absorbs both C and O, thus giving an iron of inferior magnetic quality. Electrolytic iron melted *in vacuo* is found to be superior to any existing grade of iron, the results obtained being summarised in the table on the opposite page.

The max. permeability is seen to reach 19,000 for a flux-density of 9500 gauss, while the hysteresis loss is less than half that of the best grades of commercial transformer iron, two samples of which were examined in the same way as the other specimens for the sake of comparison. The low electrical resistance is a defect which may be remedied by the addition of Si or Al. These elements increase the electrical resistance without materially affecting the magnetic quality of the iron, and experiments on such alloys

RODS THOROUGHLY ANNEALED AT 900° C.

Description of Iron.	Furnace used for Melting.	Carbon % (Analysis).	Max. Permeability.	Flux Density for Max. Permeability.	Hysteresis Loss (Ergs per cm. ³ per Cycle).		Coercive Force for B _{max} = 15,000.	Retentivity for B _{max} = 15,000.	Spec. Resist. at 90° C. (microhms.-cm.)
					B _{max} = 10,000.	B _{max} = 15,000.			
Electrolytic	Vacuum	0.0104	19,000	9500	815	1640	0.39	12,100	10.00
"	"	0.0110	16,500	8500	890	1860	0.33	13,500	9.96
"	"	0.0080	16,000	6500	895	1600	0.30	10,600	10.30
"	"	0.0130	15,400	8000	903	1710	0.31	9100	9.90
"	"	0.0130	13,100	8900	990	1760	0.33	9100	10.02
"	"	0.0136	13,900	8500	1166	2180	0.40	10,300	9.86
"	"	0.0080	13,600	8500	956	1860	0.29	9000	9.70
"	"	0.0150	13,360	8000	993	1880	0.33	9000	10.16
"	"	0.0110	13,000	9000	1340	2600	0.36	10,100	10.16
"	"	0.0080	11,900	8000	1190	2130	0.35	9000	10.05
"	"	0.0089	11,600	9000	995	1940	0.30	9000	9.70
"	"	0.0086	11,360	4500	1156	2180	0.40	10,000	10.00
"	"	0.0080	11,060	8500	—	—	—	—	9.94
"	"	0.0080	10,500	9000	1470	2640	0.40	10,500	9.87
"	"	0.0450	8000	4000	1355	3000	0.40	9500	10.80
Average	0.0126	13,980	6550	1060	1980	0.34	9940	9.96
Average for iron melted in resistance furnace	0.1000	1965	3830	—	—	—	—	13.53
0.05 % C. added	Vacuum	0.0130	6000	6000	1405	2300	0.40	10,000	10.24
0.10 % C. "	"	0.0130	7600	7000	1710	3130	0.50	10,700	10.64
0.50 % C. "	"	0.1310	4400	5500	1910	—	—	—	13.40
Swedish charcoal iron remelted in vacuum ..	"	0.0080	10,350	7000	1290	2640	0.43	11,200	10.30
Commercial Grades.									
Swedish charcoal iron cut from plate		0.1630	4876	6600	2460	4580	0.35	8000	10.57
Standard transformer steel ¹		—	3850	7000	3330	5210	1.33	9800	11.09
4 % silicon steel ¹		—	3400	4800	2930	3080	0.88	5400	51.15

¹ Received manufacturer's standard annual.

are now proceeding. A table giving the results of mechanical tests on the different specimens of iron employed, as well as a number of microphotographs are included, while in the Appendices are photographs and a detailed description of the apparatus together with an extensive bibliography of the subject.

J. W. T. W.

1617. *Appearance of Galvanic Resistance in Supra-conductors when brought into a Magnetic Field.* H. K. Onnes. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 987-992, April 28, 1914. Communication No. 189f. from the Phys. Lab., Leiden.)—In the author's last paper dealing with supra-conductors [Abstract No. 1121 (1914)] he had taken into consideration the possibility that resistance might be generated in such conductors by a magnetic field, and the behaviour of the magnet therein described seemed to show that the effect, if produced, would be very small. The field of the coil in that case amounted to several hundred gauss. In the experiments now described it was found that a coil with tin wire prepared in the author's manner showed a considerable resistance in a field of 10 kilogauss when cooled to 2° K., and this resistance decreased more slowly than proportionally when the field was reduced to 5 kilogauss. A lead coil which had shown the super-conducting effect was then placed in the cryostat in such a position that the plane of the windings coincided with the lines of force of the applied field. This coil remained super-conducting with $\frac{1}{2}$ amp. passing through it. Then the magnetic field was applied (10 kilogauss), and there was at once a considerable resistance; the sudden change takes place at >500 and <700 gauss, both for 4.25° K. and for 2° K. The introduction of the magnetic field has apparently the same effect as heating the conductor. In the case of tin, the same behaviour is observed, but the sudden change takes place at a lower value of the field (ca. 200). This effect is being still further investigated.

L. H. W.

1618. *Diamagnetic Properties of the Elements follow a Periodic Law.* P. Pascal. (Comptes Rendus, 168. pp. 1895-1897, June 22, 1914.)—Previous investigations, partly unpublished, have led to the determination for each element of a coefficient of atomic magnetisation, χ_A , which remains constant in compounds of simple structure, and is in many cases identical with that furnished by direct study of the element. The curve constructed with the atomic weights as abscissæ and the values of $\log \chi_A$ as ordinates consists of a series of regular broken lines which are of similar aspect and are reproduced periodically. Elements with atomic weights less than 20 and also the magnetic elements are not in accord with this arrangement. On the broken lines, homologous points correspond exactly with the homologous elements of the same natural family, S, Se and Te being situated at minima, and Cl, Br and I at one set of maxima and P, As, Sb and Bi at another set. Further, the curves connecting homologous points are in all cases rectilinear.

T. H. P.

1619. *On the Non-cyclic Change.* L. Steiner. (Terrestrial Magnetism, 19. pp. 78-80, June, 1914.)—The non-cyclic change as defined by Chree is the difference of the two consecutive midnight-values of the magnetic elements on a quiet day. Instead of taking the difference of the midnight-values the author has taken the difference of the daily means on two consecutive quiet days. He has chosen the observations at the magnetic observatories of the

U.S. Coast and Geodetic Survey, the uniformity in the selection of the quiet days for the different places being thus presumably best secured. The geographical positions of these places are :—

	Latitude (North).	Longitude (West of Greenwich).
Sitka.....	57° 08'	185° 20'
Baldwin	88 47	95 10
Cheltenham	88 44	76 51
Honolulu... ..	21 19	158 04
Vieques, Porto Rico.....	18 09	65 26 (old location)

In a table are given the mean values of the differences of the daily means on two consecutive quiet days. The striking thing is the general constancy of sign (and in general, too, its amount for the same station) of the difference in H (+) and in V (—): the sign and amount of the difference in D is very changeable. In another table is given the distribution of the signs of the differences. There are further set out the differences of the daily means (for horizontal and vertical intensity) on each two consecutive quiet days for Pola, Potsdam, and O'gyalla for a few years. Some attempts with Tokyo, Manila, and Mauritius did not give as definite a result, but throughout there is a tendency for the plus sign of the difference in H , and the minus sign in that in V . From the two consecutive midnight-values on calm days for Zikawei 1904-1907 there is a similar strong tendency. Although the calculations embrace only a few years yet they show the general tendency towards regularity of the differences of daily means on two consecutive quiet days. If on two consecutive quiet days there is formed the difference for every hour there is obtained what may be considered as the "non-cyclic" change for the different hours. Forming the difference of every hour and diminishing these differences by the difference of the daily mean values on these two consecutive quiet days, we get the diurnal inequality of the non-cyclic change. This diurnal inequality shows how the difference of the daily means on the two consecutive quiet days originated.

Proceeding in this way the expectation of finding a regular daily inequality has not been entirely fulfilled. Although there was a tendency to regularity, a definite result did not ensue. But things changed when those pairs of consecutive quiet days whose differences were positive, were separated from those with negative differences. A regular inequality was found, which may be expressed as follows:—

From the morning hours (about 7h. to 9h. a.m.) to the afternoon hours (4h. to 6h. p.m.) the differences are of the same sign as the difference of the daily means; during the night hours they are of contrary sign. Or, in other words, if the difference of the daily means on two consecutive quiet days is $+ -$, then the differences from morning (about 7h. to 9h. a.m.) till afternoon (about 4h. to 6h. p.m.) are $> <$, and during the night (about 6h. p.m. to 7h. a.m.) they are $< >$ than the difference of the daily means.

This rule holds good for the declination as well as for the horizontal and vertical intensity. For Sitka the rule is not so conspicuous as for the other stations to which the investigations apply. As a sample the results are given for Baldwin in 1907 in a table in the original. In the second column is the mean value of the differences on two consecutive quiet days, in the third column the number of those pairs of days, from which the results have been derived. The daily inequality values given are smoothed-out values, obtained by the formula $(a + 2b + c)/4$.

The possibility remains that the inequality, stated above, may be only a consequence of the fact that, in general, the elements are changing more during the daytime than during the night.

E. O. W.

1620. *The C. I. W. Combined Magnetometer and Earth Inductor.* J. A. Fleming and J. A. Widmer. (Terrestrial Magnetism, 18. pp. 105-110, Sept., 1918.)

1621. *Improvement of Appliances for Measurement of the Earth's Magnetic Elements.* L. A. Bauer. (Terrestrial Magnetism, 19. pp. 1-18, March, 1914. Progress Report of Department of Terrestrial Magnetism of the Carnegie Inst. of Washington.)—From the information given in the Report it appears to be theoretically possible to construct an apparatus for measuring, by electrical means, the intensity of the earth's magnetic field more expeditiously and, in general, with greater accuracy than with present magnetic methods, provided the necessary precautions be taken. Up to the present time, as far as is known, no such apparatus has as yet been put in final form, or at least no series of comparisons with the best type of modern magnetometer, sufficiently accurate and extensive, has been published. Considerable experimentation will yet be required before the question can be seriously considered whether it will be entirely advantageous, even for observatory purposes, let alone field work, to replace the present magnetic methods by electrical ones. It is believed that the greatest gain to science will ultimately result if the electrical devices be regarded as supplementing rather than supplanting the present magnetic instruments.

L. H. W.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1622. *Absolute Measure of Röntgen Rays and γ -Rays in Biology.* B. Szilard. (Archives d'Él. Médicale, 22. pp. 24-51, July 10, 1914.)—It is proposed that in future, measurements of Röntgen and γ -rays employed biologically shall be made by the ionisation method, and that the value of these forms of energy shall be expressed in the number of ions they are capable of creating. The biological unit chosen is that quantity of energy capable of producing 10^{10} ions in air under normal conditions. It is proposed to call this unit a mega-megaion. The qualitative unit of the rays is to be their coefficient of absorption by air. An apparatus is described in detail, by which the absolute values can be read directly by means of an indicator which moves over a scale graduated in the above units. This apparatus acts independently and at a distance from the installation producing the Röntgen rays. It indicates directly and exactly, without any calculation, the value of energy at the surface. From this, by means of the deduced formulæ the absolute value of the energy on a unit surface or in a unit volume at any depth may be calculated by multiplication or division, or may be obtained by simply reading from the curves which are given.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1623. Atomic Weights. **F. H. Loring.** (Chem. News, 109, pp. 169-170, April 9, 1914.)—Probably the chemical elements can be broadly divided into two classes: (1) Whole-number atomic weight elements which have no associates differing from them in atomic weight; (2) whole-number atomic-weight elements composed of, or containing, chemically non-separable associates of different atomic weight. The author gives a list of elements with their experimental atomic weights built up out of whole numbers of "meta-elements" or "isotopes." Thus:

$$\text{Chlorine} = (40 \times 1 + 85 \times 10)/11 = 85.4545.$$

$$\text{Iron} = (55 \times 1 + 56 \times 10)/11 = 55.90;$$

whereas cobalt = 59.00. In some cases the atomic weight thus arrived at is common to two or three elements. This would be fatal to the scheme but for parallel cases among the radio-elements, suggesting that though the atomic weights are the same, the electric or electronic systems may differ.

E. E. F.

1624. Active Nitrogen. **H. B. Baker, E. Tiede, R. J. Strutt, and E. Domcke.** (Nature, 98, p. 478, July 9, 1914.)—The experiments of Tiede and Domcke and of Strutt and Baker were repeated each in the presence of the other pair of investigators. As a result it appears that a sample of nitrogen may be made to give the glow more easily if it is mixed with a trace of oxygen. On the other hand, the purest nitrogen with which all the authors have worked in the joint experiments in London is capable of giving a brilliant glow under the experimental conditions used by Baker and Strutt. [See Abstract No. 979 (1914).]

L. H. W.

1625. Thermoelectric Method for the Determination of the Purity of Platinum Ware. **G. K. Burgess and P. D. Sale.** (Washington Acad. Sci., Journ. 4, pp. 282-287, June 4, 1914. Paper read before the Amer. Chem. Soc., April 6, 1914.)—The classification of platinum ware as to purity in terms of its evaporation at a definite temperature, say 1200°, appears to give doubtful results, and necessitates a tedious and delicate operation, while the application of the temperature coefficient of electrical resistance, which is diminished by any admixture, yields the most exact indications, but is convenient only with wire. The following thermoelectric method is accurate and rapid and does not deface the objects tested. To the rim of the crucible, for instance, are soldered two pure Pt-wires, 0.1-0.2 mm. in diam., which are connected with an ordinary pyrometer galvanometer or millivoltmeter. One junction is heated by a small oxygen-gas or other blast flame, whilst the other is kept cool by an air blast, radiation being prevented by the interposition of an asbestos sheet suitably shaped. Temperatures are measured by means of a thermocouple of Pt and Pt containing 10% of Rh. If it is thought advisable, the pure Pt-wires may be placed simply in contact with the crucible and not soldered; they are suitably made of Heraeus normal thermo-element wire drawn down. A number of specimens of platinum have been examined by this method, the e.m.f. of pure Pt against the crucible being calculated as iridium-content. In a few instances, the stated and found iridium-contents

agree exactly, but these often diverge widely, and in only one case was less Ir found than stated. The method is accurate to 0.01 %, but it does not distinguish the various impurities. Where stiffness is required in platinum crucibles, it would probably be preferable to add Rh instead of Ir, owing to its lesser volatility.

T. H. P.

1626. Freezing-point Diagram of Lead-Arsenic Alloys and Melting-point of Arsenic. W. Heike. (Int. Zeitschr. Metallg. 6. pp. 49-57, April, 1914.)—The author has heated lead and arsenic together in an evacuated porcelain tube heated in a furnace capable of continual rotation, the fused mass being thus kept well mixed. In contradiction of the results of earlier work, it is found that the two constituents are completely miscible in the liquid state, whilst crystalline As is completely insoluble in crystalline Pb and the latter soluble in the former only to a minimal extent. The freezing-point diagram consists of two branches meeting in a eutectic point at 288°, the corresponding proportion of As present being 8.25 atom. per cent. Although the highest proportion of As that could be obtained in the alloys was 82.8 atom. per cent., extrapolation of the eutectic time curve indicates that no chemical compounds are formed and that the melting-point of As is 852°. T. H. P.

1627. Cracking of Drawn Brass. E. Jonson. (Eng. Record, 69. pp. 415-416, April 11, 1914. Mech. Eng. 84. pp. 153-154, Aug. 14, 1914.)—Cracking is more likely to occur in a hard than in a soft alloy, especially when hardened with tin and iron. Season cracking occurs only in copper alloys that have been cold-worked. Ten per cent. aluminium-bronze hot-rolled bars did not suffer from season cracking whilst cold-drawn bars of the same material did crack. In the new Catskill (New York) aqueduct hundreds of studs have been found cracked, the cracks occurring in the unthreaded portion, and only a few studs had cracks in the thread, which indicates that machining off the surface as is done in cutting threads eliminates the danger of cracking.

It is supposed that season cracking is a bursting due to initial stress augmented by temperature stress. Some results are given of the differences in length of a cold-drawn manganese-bronze rod resulting from cutting down the diameter, and the total stress in each layer is calculated.

Specifications for rolled, extended and drawn brass are proposed.

C. O. B.

1628. Study of the Annealing Process for Malleable Castings. O. W. Storey. (Metallurgical and Chem. Engin. 12. pp. 888-889, June, 1914.)—Contains the results of experimental work carried out by E. L. Leasman under the author's direction to determine the effect of packing materials, temperature of annealing, time of annealing, and rate of cooling on the annealing process. A large number of packing materials were used including lime, sand, alundum, rolling-mill scale, resistor carbon, manganese dioxide, cement, fine and coarse fireclay, iron oxide, alumina, fine graphite, and carborundum. The results obtained with these materials showed that (1) the nature of the packing material does not influence the interior of "black heart" malleable cast iron; (2) the ordinary packing materials do not directly affect the skin structure of malleable cast iron; (3) a loose packing material, allowing a free circulation of oxidising gases will result in a carbonless rim; (4) a slightly oxidising atmosphere will result in a steely rim; (5) a neutral atmosphere will result in a rim having the same structure as the interior of the iron.

With regard to the temperature required, it was found that with an

annealing time of 50 hours, a temperature of 880° was required to secure a complete breakdown of the cementite; no decomposition could be observed in specimens annealed below 870° ; annealing at 740 – 760° for 50 hours resulted in a partial breakdown.

The results of the experiments made to determine the correct time of annealing at various temperatures showed that a malleable structure was obtained in 86 hours at 870° . By raising the temperature to 985° the time necessary was only 18 hours, whereas at 740° the necessary time was 70 hours. The lower temperatures give better results and cost less in upkeep of furnaces. The rate of cooling was found to have considerable influence on the product: a fast rate results in a steely structure, whilst a very slow rate results in a ferrite rim. The critical range of cooling is between 740° and 880° and if the rate of cooling in this range is sufficiently slow, all the carbon in the undecomposed austenite will be precipitated in this range and the rate of cooling below 700° has little effect. The mechanism of the breakdown of the iron carbide has been studied and the present results seem to show that cementite does not break down directly, but decomposes from the solid solution or austenitic condition.

C. O. B.

1629. *Three-metal Bronzes*. A. M. Blow. (Metallurgical and Chem. Engin. 12. pp. 461–466, July, 1914.)—A study is made of the effect of adding lead, zinc, phosphorus, manganese, aluminium and iron to bronze. Equilibrium diagrams of the various systems are given and the changes taking place during solidification and cooling are used to explain the effects produced. Bronzes containing appreciable quantities of lead are known as plastic bronzes.

The effect of lead on the physical properties and microstructure of bronze is simple and a fourth metal is often added to make the desirable properties more pronounced. Under normal conditions, the only difference between a high- and a low-lead bronze is the amount of lead distributed throughout the mass after solidification. Microscopically, plastic bronze shows black patches of lead set in a ground mass of bronze and in this respect it differs from most anti-friction alloys. In making plastic bronze it was found that nickel, sulphur, or phosphorus prevents the segregation of copper and lead. Other than for bearing metals, lead affects bronze by giving it superior machining properties, also giving it a patina much appreciated in bronze statuary.

With regard to the action of zinc on bronze, small quantities such as 2% cause little effect on the structure, and the physical properties are only slightly altered. With more zinc quite different alloys are produced, and with 40 per cent. zinc and a little tin, Muntz metal structure is obtained. One of the principal effects of zinc on bronze is the greater ease of cold-rolling and forging. The addition of phosphorus to bronze greatly increases its hardness or resistance to wear, but the tensile strength, elastic limit, and elongation are impaired in proportion to the phosphorus added.

C. O. B.

1630. *Change of Phase under Pressure*. I. *The Phase Diagram of Eleven Substances with Especial Reference to the Melting Curve*. P. W. Bridgman. (Phys. Rev. 8. Ser. 2. pp. 126–141, Feb., and pp. 158–208, March, 1914.)—The data presented cover a pressure-range up to 12,000–18,000 kg./cm.² and a temperature range from 0° to 200° . Over this entire range the relation between melting-temperature and pressure has been measured, and the

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difference of volume between solid and liquid has been determined. Eleven substances were experimented with, including simple and complicated organic compounds, and three elements—namely, potassium, sodium, carbon dioxide, chloroform, aniline, nitrobenzene, diphenylamine, benzene, carbon tetrachloride, *o*-cresol, and phosphorus. The effect of pressure on the melting-point may be illustrated by the following examples—

	Pressure = 1	6000	12,000 kg./cm. ² .
Potassium.....	62.5°	185.4°	179.6° C.
Sodium	97.6°	142.5°	177.2°
Carbon dioxide	— 56.6°	88.1°	98.5°
Chloroform	— 61.0°	82.4°	107.9°
Aniline	— 6.4°	98.2°	165.8°
Nitrobenzene	5.6°	122.8°	198.6°
Diphenylamine	54.0°	180.9°	—
Benzene	5.4°	181.2°	—
Carbon tetrachloride	— 22.6°	149.5°	—
<i>o</i> -Cresol.....	80.8°	102.9°	—
Phosphorus	44.2°	191.9°	—

Four of the substances were found to exist in new solid forms under high pressures, namely, CCl_4 (two new forms), *o*-cresol, benzene, and phosphorus (two forms). One of the new forms of phosphorus transforms itself reversibly into yellow phosphorus under proper conditions, while the other is stable under atmospheric conditions. It is obtained from yellow phosphorus irreversibly at 200° and 12,000 kg., but could not be obtained in the same way from red phosphorus. The new form of phosphorus is greyish-black like graphite, breaks with a similar greasy-looking fracture, and will mark on paper. It is stable in the air although slightly deliquescent, is ignited with difficulty by a match, and cannot be exploded with a blow from a hammer as red phosphorus can. It is a conductor of electricity and a rectifier. It has a very high density, 2.69 against 2.34 for red and 1.9 for yellow phosphorus. If sealed into a heavy glass capillary and heated it sublimes and condenses to yellow and red phosphorus in the colder parts of the tube exactly as red phosphorus powder does under the same circumstances. The chief object of the research was to determine the form of the melting-point curve with change of pressure and in particular to test two rival theories as to the ultimate fate of the curve, viz. whether a critical point is reached at which liquid and solid become identical or whether (as Tammann supposes) the curve reaches a maximum melting-point and then falls again. All the data now recorded agree in showing that there is no evidence for either a critical point or a max. melting-point. The results suggest strongly, so far as such a conclusion can be suggested by results over a limited range, that the melting curve continues to rise indefinitely to higher pressures and temperatures. In any case, the pressures now reached exceed considerably those that have been predicted for the supposed critical point and the supposed maximum, which can therefore only exist, if at all, in the most extreme ranges of pressure.

T. M. L.

1631. *Influence of Colloids and Fine Suspensions on Solubility of Gases in Water.* IV. *Solubility of Nitrous Oxide at Pressures lower than Atmospheric.* A. Findlay and O. R. Howell. (Chem. Soc. Journ. 105. pp. 291-298, Feb., 1914.)—Measurements are given of the solubility of nitrous oxide at low pressures from 250 to 1000 mm., overlapping with and extending the observed. VOL. XVII.—A.—1914.

vations already made under pressures from 750 to 1400 mm. [Abstract No. 1167 (1910)]. In every case a minimum of solubility was observed at some intermediate pressure, although in the case of water containing silicic acid the minimum is very shallow. Nitrous oxide gave a well-marked minimum in starch solutions, although none appeared when CO₂ was used: the exceptional behaviour of CO₂ with starch calls for further investigation. [See Abstract No. 1870 (1918).]

T. M. L.

1632. Colours of Cobalt Salts in Solution. J. E. Marsh. (Chem. News, 109. p. 171, April 9, and p. 193, April 24, 1914.)—A solution of sodium chloride and cobalt chloride in a mixture of water and acetone, which is pink when cold, separates on warming into two solutions, the upper one being light blue in colour and the lower dark blue. The upper layer is expelled gradually, and the lower layer changes its colour gradually as the temperature is raised. The solutions will mix again on cooling to the original homogeneous pink solution. When cooled without mixing the upper layer becomes almost colourless, but becomes blue again on warming, while the lower layer changes from blue to pink. The concentration of the solution may be varied within certain limits. A good effect is given by taking the salts in the proportion of 2NaCl to CoCl₂, and about equal volumes of acetone and water. Cobalt chloride alone without the sodium chloride will bring about the separation in much the same way, but a higher temperature is required.

Potassium and cobalt bromides in acetone and water give much the same effect. With lithium and cobalt chlorides the solution when cold is blue. On warming, the light and dark blue layers are obtained, and on cooling without mixing the upper layer retains its colour, while the lower layer changes from blue to pink.

T. M. L.

1633. Note on Osmotic Pressure. W. R. Bousfield. (Roy. Soc., Proc. Ser. A. 90. pp. 41–45, April 1, 1914.)—The conception that the vapour in the molecular interspaces of a solution behaves on compression of the solution approximately as a perfect gas leads to the same general result as that which is derived from thermodynamical considerations.

L. H. W.

1634. Osmotic Compressibility of Emulsions considered as Fluids with Visible Molecules. J. Perrin. (Comptes Rendus, 158. pp. 1168–1171, April 27, 1914. **R. Constantin.** (Comptes Rendus, 158. pp. 1171–1173, April 27, 1914.)—If van der Waals' equation be considered to hold good for the osmotic pressure of emulsions, it is possible to deduce a relationship between the number of particles in unit volume of a homogeneous emulsion and the constants of the van der Waals equation. The equation also involves the Avogadro-number, which gives the actual number of molecules in a gm. molecule of any substance. The correctness of the equation was tested by counting the number of granules at different heights and plotting out two functions of these as a straight line (in agreement with theory), of which one intercept gave the Avogadro-number. Using spherical granules of gutta-percha of radius 0.88μ the granules were photographed with a horizontal microscope, the focus of which included a thickness of 8 to 5μ . The granules in a series of horizontal strips of 2.77μ in height were counted on three negatives to the number of 26,000. Twenty-six concentrations were thus measured, ranging from 0.0028 to 0.0760; large and increasing deviations from the simple van't Hoff law were observed at concentrations over 0.0075, but the van der Waals equation gave concordant figures at least up to 0.0800.

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The chief results obtained were as follows :—(1) The Avogadro-number was found to be 60×10^{23} as compared with the value 65×10^{23} obtained by other methods. The constant a has a *negative* value, i.e. *the granules repel one another*. This repulsion can be explained as electrical in origin, provided that the thickness of the electrical double-layer on the surface is not negligible, and might have been foreseen from the theory put forward by Gouy in 1910.

T. M. L.

1635. *Classification of Foaming Solutions.* S. A. Shorter. (Phil. Mag. 27. pp. 718-720, April, 1914.)—The author classifies such solutions under three heads: (1) Surface concentration thermodynamically reversible; special superficial viscosity or rigidity absent. (2) Surface concentration thermodynamically irreversible; special superficial viscosity or rigidity absent. (3) Surface concentration thermodynamically irreversible; the surface layers specially viscous or rigid.

L. H. W.

1636. *Chemical Constants of Hydrogen.* v. Kohnner and P. Winternitz. (Phys. Zeitschr. 15. pp. 898-897, April 15, 1914.)—The calculation of the integration constant or "chemical constant" of Nernst's vapour-pressure formula requires a suitable heterogeneous reaction in which the gas considered is the only one taking part. For hydrogen such a reaction is furnished by the reduction of mercuric oxide by hydrogen, which was studied by Brönsted [see Abstract No. 1188 (1909)]. Brönsted's data lead to the value -1.808 ± 0.15 for the chemical constant, kinetic considerations indicating the number, -1.17 .

T. H. P.

1637. *Nernst's Approximation Formula.* P. Winternitz. (Phys. Zeitschr. 15. pp. 897-899, April 15, 1914.)—If Q represents the molecular heat of evaporation or dissociation and T the temperature at which the vapour or dissociation pressure equals atmospheric pressure, the ratio $Q : T$ should, according to the laws of Trouton and of le Chatelier and Forcrand, be constant. On the other hand, Nernst's approximation formula for vapour pressure indicates that the above ratio cannot remain constant at either very high or very low temperatures. It is found experimentally that for hydrogen and for tungsten the values of $Q : T$ are 15.0 and 41.0 respectively. Since the corresponding values derived by means of Nernst's formula are 17.0 and 42.2, the conclusion drawn from this formula is in good agreement with the experimental results.

T. H. P.

1638. *Theory of the Dissociation of Gases.* O. Stern. (Ann. d. Physik, 44. No. 4. pp. 497-524, June 4, 1914.)—A mathematical paper which cannot be usefully abstracted.

L. H. W.

1639. *The Theory of Electrolytic Dissociation.* S. Arrhenius. (Chem. Soc., Journ. 105. pp. 1414-1426, June, 1914. Faraday Lecture.)

1640. *Mercurous Sulphate for Standard Cells.* (Ann. d. Physik, 44. No. 5. p. 816, June 19, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—At the suggestion of the Reichsanstalt, Messrs. E. de Haën have undertaken to prepare mercurous sulphate on a commercial scale, following the instructions given them. The mercurous sulphate is kept under a saturated solution of cadmium sulphate, so that it may be used at once for Weston normal cells. The firm adopts the precipitation method and obtains a permanent prepara-

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tion. The entire quantity prepared is submitted to the Reichsanstalt, where its behaviour is tested by making up standard cells with it which are kept under observation for from 2 to 8 months.

F. E. S.

1641. Chemical Action that is Stimulated by Alternating Currents. S. G. Brown. (Roy. Soc., Proc. Ser. A. 90, pp. 26-82, April 1, 1914.)—Some experiments are described with the object of showing that the polarisation of a simple voltaic cell (Zn and C in dilute sulphuric acid) is completely removed by passing an alternating current of suitable strength through the cell. Certain applications are discussed, but it was found that in no case was a relay effect obtainable, the d.c. output being always smaller than the a.c. input. Platinum and also gold wires are oxidised under the combined action of the two currents.

L. H. W.

1642. Electrolytic Rectifiers. G. Schulze and R. Lindemann. (Phys. Zeitschr. 15, pp. 254-280, March 1, 1914.)—The authors criticise Zenneck's conclusion [Abstract No. 172 (1918)] that the rectifying action is due to diffusion, and that this explains the failure of the cells to rectify very rapidly alternating currents. They incline to a theory involving electronic processes in an excessively thin gaseous layer formed on the surface of the valve metal. They show, theoretically and experimentally, that Zenneck's results are explained on this view if due account is taken of electrostatic capacity and of the minimum p.d. required for transmission of currents in the unopposed direction. Some rectifying action ought to remain even at the frequencies of wireless telegraphy.

E. E. F.

1643. Polarisation in the Aluminium Rectifier. C. W. Greene. (Phys. Rev. 8, Ser. 2, pp. 264-272, April, 1914.)—The author, with the aid of a rotating contact-maker, has measured by a potentiometric method the counter-e.m.f. of an Al rectifying cell at various extremely short intervals of time after charging has taken place. The cathode used was Pt; ammonium aluminium sulphate and potassium dichromate were employed as electrolytes, although no reason is given why these were chosen. The max. applied voltage in no case exceeded 19 volts, and only direct current was applied, so that only the effect of diffusion (decay with time) is studied [not the complex rectifying process such as occurs with alternating current]. The author summarises his conclusions as follows:—(1) The condenser method of measuring the counter-e.m.f. introduces an error due to the taking of a charge from the rectifier. (2) The rectifier does not behave as an ordinary condenser. (3) When Al is used as the anode, the counter-e.m.f. alone accounts for the reduction of the current to its exceedingly small value. (4) The results obtained in this investigation are apparently in accord with the gas film theory and the theory of ionic diffusion.

L. H. W.

1644. Electrochemical Properties of RaB and ThB. Z. Klemensiewicz. (Comptes Rendus, 158, pp. 1889-1891, June 22, 1914.)—The author has made experiments on the question of the similarity of RaB, ThB, and lead. The method employed consisted in the determination of the ratio of partition of the radio-active substance between the amalgam of lead and a solution of lead nitrate. From the results it is concluded that the normal electrochemical potentials of RaB and ThB differ from each other and from lead by less than 2×10^{-6} volt.

E. M.

1645. *Electrolytic Deposition of Metal in (Electrolytic) Valve Cells.* G. Schulze. (Ann. d. Physik, 44. 7. pp. 1106-1120, July 17, 1914. Communication from the Physikal-Techn. Reichsanstalt.)—When a tantalum electrode immersed in a solution of copper sulphate is submitted to the action of an alternating current, it undergoes "formation." After the formation, only a definite fraction (about 85 %) of the total copper is deposited in the electrochemically active form when the "flow current" passes (Ta kathode); the remainder deposits as a fine powder in the electrolyte. The Ta remains blank. The electrochemically active copper is again dissolved when the "throttled current" begins to pass, the cell remaining open; as soon as the copper has dissolved the cell becomes closed.

The amount of copper which is deposited in the active form is almost independent of (a) the "formation" tension or the thickness of the active layer of the Ta, (b) the current density, when high current densities are used, (c) the concentration of the electrolyte. It increases with the temperature, with diminishing current density for low current densities, and with decreasing strength of the acid from which the salt used is derived. The addition of other electrolytes to the solution of copper sulphate diminishes the total amount of copper deposited all the more, the lower its minimal tension is. For example, if a 0.4 mol. CuSO_4 solution is made 0.08 mol. with respect to sodium sulphate, not copper, but sodium is deposited, which then liberates hydrogen from the water.

When the kathions of the heavy metals are arranged in a series depending on the fraction of the metal which is deposited in the electrochemically active form, the order is the same for the nitrates, sulphates, and acetates of these metals. Since Ta is "formed" by the alternating current in solutions of the salts of heavy metals, it is probable that the observed phenomena are connected with the existence on the tantalum of a layer of oxide of molecular thickness.

Aluminium exhibits the same behaviour as Ta, but in an incomplete manner, since in the electrolytes used the valve action does not exist or is incomplete. [Compare Abstract No. 1565 (1918).] T. S. P.

1646. *Passivity of Metals.* G. Senter, G. Grube, G. Reichinstein, H. S. Allen, M. Le Blanc, G. C. Schmidt, G. Schulze, A. P. Schoch. (Faraday Soc., Trans. 9. pp. 208-290, March, 1914.)—This discussion includes papers on various aspects of the theory of passivity, contributed by the authors enumerated above. L. H. W.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1914.

GENERAL PHYSICS.

1647. *Instrument for recording Pressure Variations due to Explosions in Tubes.* J. D. Morgan. (Phys. Soc., Proc. 28. pp. 172-177; Discussion, p. 177, April, 1914.)—A light steel vane of rectangular form is mounted parallel to the explosion tube in a cell presenting a lateral opening to the tube interior. Along three edges the vane is free, and along the fourth edge it is attached to a torsion wire. The vane, which is fitted with a dash-pot, is made to fit the cell as closely as possible around its edges without touching the sides of the cell. The diagram is produced by a style on a smoked paper strip wrapped around a clock-driven drum, and on the same strip is described a time curve by an electrically-driven tuning-fork of known frequency.

L. H. W.

1648. *Direct Measurement of the Napierian Base.* R. Appleyard. (Phys. Soc., Proc. 28. pp. 178-182; Discussion, p. 182, April, 1914.)—A description of a simple apparatus intended to convey to students an idea of the way in which the base e of the Napierian logarithms enters into physical problems in a specific case of wide application. A small length of chain is allowed to hang from a loop of thread, and the remaining part of the chain is then pulled aside until the thread is at 45° to the vertical. The curved portion becomes a true catenary when the angle between the vertical and curved portions of the chain at the attachment of the loop is 90° . To ensure that this condition is reached the circle of curvature of the catenary at that point is drawn, and this is found to have a radius equal to the vertical portion. In these circumstances, if the vertical length is taken as unity, and if its lower end is taken as origin, it is shown that e is the sum of the y -ordinate at $x = 1$, and the length of curved chain between the point where that y -ordinate cuts the curve and the top of the vertical portion. The application of this result to a simple representation of the relationship and meaning of hyperbolic functions is also shown, and it is urged that such functions should be studied from consideration of the catenary rather than from the hyperbola.

AUTHOR.

1649. Gyrostatic Devices for the Control of Moving Bodies. J. G. Gray. (Phys. Soc., Proc. 28. pp. 224-245; Discussion, pp. 246-247, June, 1914.)—The author describes a number of contrivances for stabilising and forcibly manoeuvring moving bodies, such as torpedoes and airships. It is not possible to understand these properly without entering into details. All the models shown are provided with complete or real stability, the stabilising forces being derived from the propelling system. [See also Abstract No. 158 (1914).] L. H. W.

1650. Reproduction and Measurement of very Short Intervals of Time. J. Coulson. (Phys. Rev. 4. Ser. 2. pp. 40-46, July, 1914.)—It is often found desirable to have at one's disposal some means by which two neighbouring electric circuits can be broken in quick succession in such a way that the interval between these two operations is accurately predictable and under the control of the experimenter. This paper contains a brief description, with diagrams, of a simple apparatus which can be made to give time-intervals of very short duration. The apparatus is based on the principle that if a massive weight, falling freely under gravity, strikes a collar on a metal rod which is supported vertically, an elastic wave or impulse travels out along the rod in each direction from the collar with a finite velocity. If the impact takes place at the middle of the rod, these waves will, of course, reach the ends of the rod at the same time. If, however, the point at which the impact occurs be not at the middle of the rod, the impulses will reach the ends at times that differ by an interval which will depend on the path-differences. In this way controllable time intervals extending over a considerable range may be secured, and can easily be measured with the aid of proper apparatus. A. W.

1651. Collapse of Tubes by External Pressure. R. V. Southwell. (Phil. Mag. 26. pp. 502-511, Sept., 1918.)—Gives results of the experimental work referred to in Abstract No. 882 (1914). An investigation is made of the causes of some discrepancies which have been noticed between the resistance to collapse of actual tubes and the values given by the author's theoretical formula. Tubes exceeding the "critical length" (Carman) are alone considered. The results of Carman's experiments on seamless brass and steel tubes are compared with curves derived by the author's theory from the stress-strain diagrams of compression tests. It is concluded from a consideration of these curves that in employing in design formulæ which have been obtained from hydraulic testing apparatus serious over-estimates of strength are being made, unless the maintenance under practical conditions of the high elastic limit which is induced by the drawing process can be relied upon. L. H. W.

1652. Collapse of Short Tubes by External Pressure. G. Cook. (Phil. Mag. 28. pp. 51-56, July, 1914.)—Describes experiments on the collapse pressure of uniform solid-drawn steel tubes, 3 in. in internal diam., of various thicknesses and of lengths ranging from 2 to 12.7 in. Each tube was closed at both ends by thick cast-iron discs, and the cylinder thus formed was placed in a chamber where it could be subjected to an external pressure up to 8000 lbs. per sq. in. while the interior was kept in communication with the atmosphere. The collapsing pressure (p_1) was found for each tube and plotted (1) against the ratio of thickness to diam. (t/d), and (2) against the length (l). A separate curve is drawn in the first series for each different

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value of l , and in the second series for each separate value of l/d . If p is the collapsing pressure of a tube of infinite length, but of the same diam. and thickness as the one under investigation, while L is the critical length, it is found from the second series of curves that the equation $p_1 = pL/l$ is more nearly satisfied by Southwell's value of $L(k\sqrt{d^3/l})$ than by Carman's (δd), but the tests are not sufficient in number, nor do they cover a wide enough range of dimensions to give definite confirmation of any theory. For these experiments the numerical value of the constant k would appear to be about 1.78 and the critical length L to vary from about 18 to 18 times the diam. [See also preceding Abstract.] J. W. T. W.

1653. *Influence of Time on the Rapid Deformation of Metals.* G. Charpy and A. Cornu. (Comptes Rendus, 158. pp. 1969-1972, June 29, 1914.)—Although the influence of time on the deformation of metals under slowly applied stresses is pretty well known, its influence in shock tests has not received much attention. The authors have endeavoured to fill this gap in our knowledge by a study of shock bending tests on notched and plain bars with the object of determining the effect of varying the height of fall, weight of the tup, and the rate of fracture on the resilience of the material. The results show that between the limits of 6 m. and 1 m. for the height of fall and a duration of deformation of between 1/1000 and 1/100 of a second the variation of the resilience is to all intents and purposes negligible, since it is well within the limits of experimental error. F. C. A. H. L.

1654. *Deformation of Rock-salt Crystals.* T. Terada. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 290-291, May, 1914.)—Describes an investigation, by means of a Röntgen-ray radiograph, of the molecular structure of a crystal of rock salt deformed while in the plastic state [see Abstract No. 1028 (1914).] A rock-salt plate was bent into a cylindrical form with one of the crystallographic axes along the generating line, and the results obtained are explainable on the assumption that the crystal, in bending, breaks up into several finite portions, each portion retaining its undeformed molecular lattice. The interspaces are probably filled up by minute crystals arranged as in the case of a fibrous substance. With a specimen pressed in boiling water between two cylindrical surfaces, it appears that the crystal is broken up into numerous small portions with irregular orientations. J. W. T. W.

1655. *Shape of Capillary Surface inside a Tube of Small Radius.* A. Ferguson. (Phil. Mag. 28. pp. 128-138, July, 1914.)—Formulæ are here obtained giving a closer approximation than usual to the outline of the surface of a liquid contained in a vertical tube of small bore. The formulæ are utilised in a discussion of the method used by Sentis for the determination of surface tensions. Applications are also made to Jaeger's method for surface-tension measurements and to a discussion of certain aspects of the experiments of Ramsay and Shields on the molecular complexity of liquids. [See also Abstract No. 844 (1918).] A. W.

1656. *Forces Acting on a Solid Sphere in Contact with a Liquid Surface.* II. A. Ferguson. (Phil. Mag. 28. pp. 149-158, July, 1914.)—Forms a continuation of a previous paper [see Abstract No. 181 (1914)] the methods of which it extends to cases in which the vertex of the sphere is not restricted to the level of the free liquid surface, but may be at any distance d_1 below it. From the results obtained the more rigid equation of equilibrium of a segment of a
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sphere floating in a liquid may be at once deduced and gives the modification to be applied to the simple Archimedean equation in order to allow for surface tension. Further, the particular value of d_1 is found for which the upward force required to keep the sphere in equilibrium is just equal to its weight in air. A method of determining surface tension based on the use of this value of d_1 is considered by the author inferior in accuracy to the method originally adopted (*loc. cit.*). A simplified form of the experiment using a plate instead of a sphere is, however, described. The plate is first balanced in air. A vessel containing the liquid is then raised until the plate just touches its surface. The further motion, d_1 , required to restore the plate to its original position of equilibrium gives the surface tension of the liquid. This forms an interesting extension of the ordinary detached-disc experiment.

J. W. T. W.

1657. Measurement of Air Velocities, Pressures, and Volumes. W. Cramp. (Manchester Lit. and Phil. Soc., Mem. 58. 7. pp. 1-16, June, 1914.)—For various reasons the anemometer is unsatisfactory in measuring air velocities; it is rather an indicator. The Pitot tube is accurate provided the facing tube is small and of such a form that stream-line flow is not much disturbed. Various tubes are compared; the Nipher collector is very inaccurate, and the Brabée tube seems superior to anything but the Standard Pitot with static tube in pipe wall. This latter involves holes with good internal surfaces to be drilled at various points and is in commercial work often impossible. The Brabée tube seems very little affected by faulty setting. In determining the volume of air passing through a pipe, the author takes the central velocity \times a coefficient to give the mean velocity. For central velocities of 6.89, 7.72, 8.58, 9.16, 9.42 m. per sec. the coefficient is 0.8, 0.9, 0.9, 0.9, 0.88 respectively. With water flow the author remarks that the coefficient is about 0.85. The Krell-Prandtl pneumometer is also described. H. S. R.

1658. Application of W. Ritz's Method to the Problem of Uniform Flow in a Square Tube. M. Paschoud. (Comptes Rendus, 159. pp. 158-160, July 18, 1914.)—J. Boussinesq treated this problem by the approximate method of Saint-Venant. The author shows how the method which was used by Ritz in discussing the equilibrium of thin elastic plates, may be applied to the problem of flow. J. Boussinesq observes in an appended note the essence of Ritz's method to be the use of a double instead of a single series with the advantage that it automatically breaks up the differential equation into easily integrable components. H. S. R.

1659. A Hydrodynamic Experiment. D. Riabouchinsky. (Boll. dell' Aero Club di Roma, 9. 1. p. 7, March, 1914. Amer. Soc. Mech. Engin., Journ. 86. p. 0122, June, 1914. Abstract.)—The phenomenon of the rotation of a rectangular plate in an air current can only be repeated in water if sufficient inertia is provided. C. A. B.

1660. Possible Dependence of Gravitational Attraction on Chemical Composition, and Fluctuations of the Moon's Longitude which might result therefrom. C. V. Burton. (Phil. Mag. 26. pp. 252-256, Aug., 1914.)—The author first refers briefly to the pendulum work of Newton and Bessel on the degree of accuracy to which the Newtonian coefficient of gravitation is a universal constant of matter independent of chemical and physical properties. He then points out that the planets of the solar system, which may be supposed to differ in composition since their mean densities are so various, should by the exactitude with which their orbits conform to Kepler's third law

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be evidence of the close uniformity of the Newtonian coefficient. The earth-moon system would most readily exhibit any departure from strict uniformity, and the author shows by a mathematical discussion that if the gravitational indices for earth and moon differ by but one part in 20,000,000, the fluctuations of the moon's longitude would comprise a term of period one lunar month and amplitude one second of arc. Hence it follows that the earth and her satellite, widely as they differ in mean density, must have, within one part in many millions, the same gravitational index. The author thinks it should be possible to speak more definitely when the short-period terms in the moon's longitude have been adequately discussed. H. H. Ho.

1661. *The Specification of the Elements of Stress*. R. F. Gwyther. (Manchester Lit. and Phil. Soc., Mem. 58. 5. pp. 1-21, June, 1914.)—A further contribution [see Abstract No. 1628 (1912)].

1662. "*Suction*" between passing Ships. S. A. Reeve. (Engineering, 98. pp. 195-198, Aug. 7; 228-281, Aug. 14, and pp. 248-245, Aug. 21, 1914.)—Deals with the subject under the following headings: History and general Theory; Ship waves and sea-contours; Interaction between two or more ships; Actual instances of suction collision. L. H. W.

1663. *Equilibrium of Revolving Liquid under Capillary Force*. Rayleigh. (Phil. Mag. 28. pp. 161-170, Aug., 1914.)—Deals with the case where the revolving mass assumes the form of a thin ring. L. H. W.

1664. *Stability of Bohr's Model Atom*. L. Föpl. (Phys. Zeitschr. 15. pp. 707-712, July 15, 1914.)—Mathematical.

1665. *American Temperatures and European Rainfall*. W. J. Humphreys. (Washington Acad. Sci., Journ. 4. pp. 845-847, June 19, 1914.)—The author has previously established that the average temperature of the earth is closely related to the sun-spot cycle, and also to the amount of volcanic dust in the high atmosphere [see Abstract No. 1586 (1918)]. It would seem, then, that many other meteorological elements must also vary according to the same period as that found in the temperature. A preliminary attempt is here described which seeks a connection between the temperature of the Eastern United States and the rainfall of Germany. A close connection is found over the period of years investigated, 1874-1913. It is pointed out that this is only what would be expected, since the prevailing wind blows from west to east across the Atlantic, and warm weather over the Eastern States of America would naturally be associated with increased evaporation in that district and greater water-contents in the air. J. S. Dr.

1666. *Climate of Eastern Siberia*. A. W. Wosnessensky and A. B. Schostakowicz. ([488 pp.], Irkutsk, 1918. Review by A. Woeikof in Meteorolog. Zeitschr. 81. pp. 161-169, April, 1914.)—In the review figures are given which show the remarkable difference between the high summer temperatures in Eastern Siberia and those found in Central Europe for the same latitude and height above sea-level. This heat is very advantageous for agricultural purposes, but is offset to some extent by the fact that though the variation of the monthly means is small for the seven stations dealt with, the absolute variation is very large. Attention is also called to the frequency with which winter temperatures of -60° C. are observed in North-eastern Siberia. L. H. W.

1667. *Seiches of Lake Towada.* (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 4. pp. 168-169, 1918.)—This is one of the deepest lakes in Japan, and of great transparency. Three sets of Honda's limnimeters were used, and simultaneous observations made at different stations. The different modes of free oscillations were studied by means of a model of the lake, the surface of the water being covered with aluminium powder which admitted of photographs being taken of the freely oscillating water; six of these are included. By comparing the above modes of oscillation with those actually observed, it was found that the largest observed period, 17.88 mins., was that of the fundamental oscillation of the lake. The various data are graphically given by twelve diagrams. H. H. Ho.

1668. *Distribution of Prominences on the Sun's Surface.* A. Riccò. (Accad. Lincei, Atti, 22. pp. 525-582, Dec. 7, 1918.)—Observations which have been conducted during three 11-year cycles have yielded no regular and precise results as regards the distribution of sun-spots, but nevertheless certain reliable conclusions can be drawn from the 88 years' consistent observations. These conclusions are summarised by the author as follows:—
 (1) In both solar hemispheres there is a zone of maximum prominence frequency at 20° to 40° of heliographic latitude, and this persists throughout the whole 11-year cycle, except near the epoch of minimum solar activity, when it is absent. (2) There is another region of max. prominence frequency which commences to become manifest about the time of the 11-year maximum, lying between 40° and 60° , and lasts till about the time of the 11-year minimum, then transports itself to higher latitudes, as far as the polar regions of the sun at the epoch of the maximum. (3) After the epoch of reduced activity, there is only a single zone (the lowest) of prominence frequency; at the time of greater activity there are two. (4) In the first zone the prominences formed are eruptive and metallic; in the other regions only quiescent, hydrogenous prominences are formed. (5) The distribution and change in latitude of the maxima during the 11-year cycle of prominences are entirely different from those of the sun-spots. (6) In each of the three cycles of the Sicilian observations the northern prominences were, in general, less frequent than the southern. In the preceding cycle, on the other hand, the northern were more prevalent than the southern. (7) The mean heliographic latitudes of the prominences were higher near the time of minimum activity, and lower at that of the maxima. (8) The mean latitudes of prominences, north as well as south, of each cycle differed little from one another and show a mean value of $84\frac{1}{2}^{\circ}$. (9) The mean annual latitudes of all the prominences, both north and south, have oscillated between $+8^{\circ}$ and -7° ; generally the negative values prevail near minimum activity, and positive near maximum activity. (10) The mean latitudes of all the prominences, taking both hemispheres together, in the three cycles, were all three positive and less than 1° . L. H. W.

LIGHT.

1669. Cyanometer. G. A. Tichov [Tikhoff]. (Acad. Sci. St. Pétersbourg, Bull. 11. pp. 809-818, June 15, 1914.)—In this preliminary note the author outlines the construction of a cyanometer by means of which a blue light may be produced with the intensities of its components, like those of the normal blue of the sky, in inverse proportion to the fourth power of their wave-lengths. T. H. P.

1670. Intermittent Vision. S. P. Thompson. (Roy. Soc., Proc. Ser. A. 90. pp. 448-449, July 20, 1914.)—In a previous paper [Abstract No. 648 (1914)] Mallock, in order to account for the intermittences seen when watching a revolving disc of black and white sectors, at the moment when a slight mechanical shock is given to the head or body, advanced the hypothesis that a slight mechanical shock produces a periodic but rapidly extinguished paralysis of the perception of light, and that the nerves on which seeing depends cannot bear more than a certain amount of mechanical acceleration without loss of sensibility.

This hypothesis of a momentary paralysis of the sense of vision seems to be unnecessary. The sector disc revolving at from 2 to 6 revolutions per sec. presents a uniform grey tint. On stamping the foot or tapping the head, the most prominent effect observed by the present author was not the momentary appearance of stationary grey or black sectors, but the enhanced brightness of stationary white sectors. A momentary paralysis, if it occurred, should produce momentary blackness of the entire disc, which is not what happens. To further test the phenomenon, a revolving sector disc, driven uniformly by a small motor, was arranged so that it could be observed either directly from a distance of a few feet or by reflection in a small mirror. When a slight shock is given to the mirror so as to alter by a small amount the apparent position of the revolving disc, an intermittence is produced of the same kind as is observed when a shock is given to the head or body. The sectors appear momentarily to stand still, and the brightness of the white sectors is for an instant enhanced. The explanation of the effect appears to be that when the moving images of the white sectors on the retina are suddenly shifted by a minute displacement, they fall on some of the rods and cones which are relatively unfatigued, and which, for the instant, are therefore of greater sensitiveness. A. W.

1671. Axial Chromatic Aberration of the Human Eye. P. G. Nutting. (Roy. Soc., Proc. Ser. A. 90. pp. 440-448, July 20, 1914. Washington Acad. Sci., Journ. 4. pp. 885-888, Aug., 1914.)—A bright object viewed directly by a normal human eye shows no perceptible coloured fringes. If the same object be viewed through a filter transmitting only the extreme red and blue, it will appear with either a blue or red fringe, showing that for these extreme rays the eye is not corrected. Helmholtz passed monochromatic light through a small hole, and found that with red light the hole appeared in best focus when viewed from a distance of about 8 ft., with blue light at about $1\frac{1}{4}$ ft., and with extreme violet at a few inches. With these rough determinations the question appears to have rested. A method is here described of obtaining rather precise determinations of axial focal length by means of very simple

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apparatus. The monochromatic rays of a Nernst, or a mercury, lamp, pass through a slit, and then through a movable lens of 20 cm. focal length, to the eye. The image of the slit formed by the lens serves as test object. In order to fix the accommodation a glass plate at 45° is placed between eye and lens, reflecting the image of a side object at the desired distance. Three eyes were tested at accommodations for 25 cm., 100 cm., and infinity; the others for infinity only. The side object should be dark, a black letter, or distant tree-trunk for instance, so that the slit may appear against a dark background. A shift of the lens 1 cm. corresponds to 0.01 mm. shift in focal point at the retina. The results for seven observers are shown in tables and curves, the axial error curve for "an eye of pure water" being also given for comparison. In the most luminous part of the spectrum, from 520 to 660, all the eyes tested show less variation in focus than an equivalent eye of pure water would have. In some eyes the correction in the central region would compare favourably with that of a good photographic or telescopic objective. Several types of correction are shown that are new to lens optics. In two cases high-order central corrections are accompanied by decreased violet but normal red correction. One case shows no correction except in the extreme red and violet, where the correction is normal. Another is slightly corrected except in the extreme regions. Another is fairly well corrected over a wide region, from 480 to 780. Some tests were made for residual chromatic spherical aberration (departure from Gauss condition) by placing half of a half-tone screen over the test slit. The author could detect no residual in his own eye from 500 to 650, but beyond 700 in the red and 480 in the blue it was noticeable, while at 406 in the violet it amounted to 20 times the normal diffusion. One observer agreed with the author, while another could detect little loss of definition at 406. A. E.

1672. *Simple Unit Method for measuring the Actinic Effect of Illuminants in the Practice of Photography.* F. M. Steadman. (Amer. Illum. Engin. Soc., Trans. 9. pp. 265-289; Discussion, pp. 289-291, March, 1914.)—The treatise of which the present paper is a brief abstract, was written in the hope of establishing a rational scientific foundation for the practice of photography and for the study of light as it is daily observed in Nature. It is shown that the chemical energy of light, the relative aperture of a lens, the degree of sensitiveness of photographic emulsions, which are the fundamental elements in photography, are at present lacking simple units of measurement. The whole system has been named "Aabacraft Photography." A term "actinism" is used, and defined to denote the chemical property of radiation, and a unit of it under specified conditions is called an "actino." A practical actinometer is described and its use explained. A unit cone system for the measurement of light convergence is developed, and the relation of such a system to the systems of lens stops, now in use, is explained; also the Hurter and Driffeld work in their analysis of what may be called a "perfect printing negative" is developed. The theory of the "characteristic curve" of a given photographic plate and the "law of constant density ratios" are gone into with considerable detail. The paper also includes a number of problems illustrating the important points considered. A. E. G.

1673. *Dynamical Theory of Diffraction.* D. N. Mallik. (Phil. Mag. 28. pp. 224-233, Aug., 1914.)—Mathematical.

1674. *A Graphic Treatment of Cusped Wave-fronts and of the Rainbow.* W. R. Bower. (Phys. Soc., Proc. 26. pp. 212-222; Communications, VOL. XVII.—A.—1914.

pp. 222-228, June, 1914.)—A method of drawing the cusped wave-fronts produced by refraction and reflection at a spherical surface and a graphic treatment of the elementary theory of the rainbow are described. The method is based upon the properties of the centre of junction. L. H. W.

1875. *On Anomalous Trichromatic Colour Vision.* W. Watson. (Roy. Soc., Proc. Ser. A. 90. pp. 448-448, July 20, 1914.)

1876. *Absorption and Refraction Indices for Thin Copper.* W. Planck. (Phys. Zeitschr. 15. pp. 568-568, June 1, 1914.)—Describes experiments on the absorption and refraction of layers of thin copper. The method adopted was similar to that used by Galli [Dissertation, Göttingen, 1918]. The chief interest of the paper lies in the tables and diagrams of the results. Theory is also given. A. W.

1877. *Damping of Oscillations in Luminous Vapours.* R. Ladenburg. (Phys. Zeitschr. 15. pp. 690-694, July 15, 1914.)—A paper discussing the method of Mandelstam and v. Ubisch [see Abstract No. 1478 (1911)] for the damping of the oscillations in luminous vapours. It appears that the method gives a value for the luminous Na-vapour about ten times as great as that found by Ladenburg and Senftleben by a method to be fully described later. A discussion of the theory of the researches of Mandelstam and v. Ubisch shows that the equations used by v. Ubisch for the calculation of the damping coefficient only hold for very rare vapours. The dependence of the absorption coefficient (and hence the intensity distribution of the sodium lines) on the frequency is also dealt with. Further, from the researches of Voigt and of Ladenburg and Reiche [see Abstract No. 1529 (1914)] it appears that the function deduced by Rayleigh from the Doppler-effect is more important for the intensity distribution of the lines investigated as the vapour becomes less dense. Consequently these lines, for small vapour densities, are characterised not so much by the damping of the oscillations as by the velocity of the luminous centres or carriers, and in this case researches on the lines of the method of Mandelstam and v. Ubisch allow this velocity to be calculated. The necessary equations for this are given. A. W.

1878. *Relation between the Emission Spectrum of a Compound and its Absorption Spectrum in Solution.* A. K. Chapman. (Phys. Rev. 4. Ser. 2. pp. 28-30, July, 1914.)—Spectrometric investigation of mercuric iodide, stannic iodide, ferrous iodide, and mercurous chloride, which are characterised by a wide emission band shading off towards both the red and the violet, indicates the existence of a definite relation between the absorption and emission bands, and it would seem that the vibrating system responsible for the emission is also effective in producing absorption in solution. T. H. P.

1879. *Absorption Spectra at very Low Temperatures.* A. Mazzucchelli. (Accad. Lincei, Atti, 23. pp. 958-959, June 21, 1914.)—In view of the fact that the bands of the phosphorescence spectra of uranyl salts become narrower and more clearly defined at very low temperatures, the author has investigated the absorption spectra of various uranyl salts at temperatures somewhat above -180° . At such temperatures solutions of the salts in ethyl alcohol solidify to transparent, glassy masses, which were used for observation; addition of glycerol or of methyl alcohol to the ethyl alcohol lowers the solidifying point considerably, but the resultant glassy masses then either disintegrate rapidly or are opaque. The absorption bands are found to become clearer and to be

displaced appreciably at the low temperatures employed ; in some cases new bands make their appearance. Examination of various colouring matters in the same manner shows that at about -180° the absorption bands differ but very slightly in position and clearness from those observed at ordinary temperatures. It seems, therefore, that the influence of low temperatures on the absorption bands is pronounced only with those compounds, the selective absorption of which is a property of one of the constituent elements. T. H. P.

1680. *Series Lines in Spark Spectra.* A. Fowler. (Roy. Soc., Phil. Trans. 214. pp. 225-266, July 18, 1914. Roy. Soc., Proc. Ser. A. 90. pp. 426-480, July 20, 1914.)—The work of Rydberg, and that of Kayser and Runge, dealt mainly with series lines in spectra which are developed in the flame or electric arc, or in vacuum tubes with discharges of moderate intensity. The lines to be discussed in the present communication are some of those which belong to the class of "enhanced" lines as defined by Lockyer ; that is, they are relatively intensified in passing from arc to spark conditions. In considering these lines it is necessary to take account of the fact that their behaviour in the arc is different for different elements. At least three classes may be recognised : (1) Enhanced lines like the H and K lines of calcium, which are well developed in the ordinary arc. (2) Lines which only appear with small intensities in the arc, such as the enhanced lines of iron. (3) Lines which do not appear in the ordinary arc (except very locally near the poles), but are strongly developed under spark conditions, as in the case of the well-known magnesium line at $\lambda 4481$. Until very recently the only evidence that enhanced lines may belong to series was that afforded by Runge and Paschen's observations of the spectra of Mg, Ca, Sr, Ba, and Ra, under the influence of a magnetic field. In the case of each of these elements three pairs of lines of class 1 were observed, and though no series formulæ could be calculated for them, the magnetic resolutions proved that one pair belonged to the Principal series, another to the Sharp, and the third to the Diffuse series. Further discussion of these series has become possible through the work of Lyman in the Schumann region.

The present investigation was undertaken in connection with the new series of lines which were produced in 1912 by passing strong condensed discharges through helium tubes containing hydrogen as an impurity. These lines, of which the strongest is at $\lambda 4686$, are of considerable importance in celestial spectroscopy because of their occurrence in the spectra of some of the nebulae, and in stars which are generally regarded as representing the earliest stages of stellar condensation. One of the series, only feebly visible, was in apparent agreement with a series of lines first observed in ζ Puppis by Pickering, and attributed to hydrogen because of their simple relation to the Balmer hydrogen series. The other was a strong series, which included the lines assigned by Rydberg to the Principal series of hydrogen from analogy with the spectra of the alkali metals. In addition to the Rydberg lines, however, the "4686" series included intermediate lines which the then recognised formulæ suggested was a second Principal series related in a simple manner to the first. As the new lines could not be obtained from hydrogen alone, and in consideration of the occurrence of lines not anticipated by Rydberg, it was soon felt that further inquiry should be made as to the value of the numerical evidence on which their assignment to hydrogen was chiefly founded. A search for other series of similar character was therefore undertaken, in the hope that some generalisation with regard to such series might be arrived at. The mode of production of the "4686" lines suggested

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spark spectra as the most promising source of such series, and, shortly afterwards, experiments on magnesium yielded some new lines of that element which were obviously associated with the spark line 4481 in series of the kind looked for. No satisfactory evidence of relation to other series of Mg lines, however, was then obtained, and it seemed possible that both the "4686" and the "4481" series were of a new type, having no necessarily simple relation to other known series in the respective spectra.

The lines of the "4686" and the associated Pickering series have since become of increased importance, in connection with theories of the constitution of the atom, through the theoretical investigations of Bohr. Beginning with the "Rutherford" model of the atom, and introducing Planck's quantum, Bohr has derived a formula for the hydrogen spectrum which excludes these lines, while agreeing closely with the hydrogen series about which there can be no doubt. The "4686" and Pickering series, however, are included in another formula, derived for the emission of He-atoms during the first stage of their re-formation when both electrons are supposed to have been removed by the strong discharges employed. This formula is identical, in a first approximation, with that for hydrogen except that the Rydberg constant " N " ($=109,675$ for Rowland's scale) has four times its ordinary value. The two "Principal" series previously assigned to hydrogen were thus united in a single formula attributed to helium, while the Pickering series was made to include intermediate lines coincident with the Balmer series of hydrogen. As the lines in question, whatever their origin, must be regarded as enhanced lines, it was evidently desirable to continue the general investigation of lines of this class. Further investigation of magnesium, in particular, was also suggested by the discovery made by Paschen, and by King, that the line 4481 is a close doublet, as it appeared that a valuable indication of the type of series to which it belongs might be obtained if other members could be resolved. Photographs with high dispersion have accordingly been taken for the resolution of the lines and to provide more accurate data for testing the formula for enhanced lines which was suggested by the work of Bohr. Other photographs, taken with smaller dispersion, have resulted in the detection of additional lines which clearly belong to series related to that beginning with 4481.

The discussion of the new data for Ca and Sr given by other observers, has led to some conclusions which are probably of general application to enhanced line series. The chief results of the investigation are as follows:—The enhanced (spark) lines of Mg, Ca, Sr, and Ba form series of doublets which occur in groups similar to those previously recognised in arc spectra. The formulæ representing these series, however, differ from those employed for arc lines in that Rydberg's constant " N " ($=109,675$ for Rowland's scale) has a value equal to $4N$. The Fundamental series, in the doublet systems of Ca, Sr, and Ba as shown by Saunders and Lorensen, derives its limit and the separation of its components from an observed negative form of the Diffuse series, and the Fundamental series, which might have been expected, do not exist. A new group of series of narrower doublets has been found in Mg, in which the separation of the Sharp and Diffuse pairs is identical with the (calculated) separation of the second pair of the Principal series of wider doublets. The new group is designated the "F.P." system: in addition to the ordinary series it includes two well-marked combination series, each consisting of seven observed lines. The "4481" series of Mg consists of very close doublets with constant separation, and forms the Fundamental series of the F.P. system. Its limits

are derived from the first negative term of the Diffuse series. Corresponding series of the F.P. and Wide doublet systems run parallel to each other, but notwithstanding this numerical relation, the two systems do not necessarily co-exist, the wider doublets occurring in the ordinary arc as well as in the spark, while the F.P. group occurs only under spark conditions or their equivalent in the region of the negative pole of an arc *in vacuo*. No numerical relations have been traced between any of the enhanced line series of arc lines of the same element. The "4686" series produced in helium tubes is of the enhanced line (4N) type, and can no longer be considered to belong to the same group as the Balmer series of hydrogen, which is of the arc (N) type. It is concluded that these lines are due to He as indicated by Bohr from theoretical considerations; it is suggested that they should be designated "proto-helium" lines. Analogy with the "4481" series of Mg indicates that the "4686" series of proto-helium is primarily of the Fundamental type: the three associated series may be regarded as coincident with it. The Pickering lines associated with the "4686" series are also probably due to proto-helium, in which case the series would include lines nearly coincident with the Balmer series. The observational evidence on this point is incomplete, but the assignment of these lines to proto-helium is supported by the fact that one of the new combination series of magnesium is related to the "4481" series exactly as the extended Pickering series would be related to the "4686" series. The slight differences between the observed positions of alternate lines of the "4686" series and those calculated by Rydberg for the Principal series of hydrogen are in very close agreement with Bohr's theoretical formulæ for hydrogen and proto-helium. Adopting these formulæ, the spectroscopic data give a provisional value for the mass of the hydrogen atom, in terms of that of the electron, as 1886 ± 12 or 1855 ± 12 when the data are corrected to the International scale of wave-lengths. The appearance of the Rydberg constant in enhanced line series with four times its usual value may be explained on Bohr's theory by supposing that series of the arc type are produced when only one electron is removed from each of the atoms involved, while in the case of enhanced lines two electrons are removed. A preliminary examination of terrestrial and celestial spectra has given no indications of series requiring still greater multiples of the Rydberg constant in the formulæ representing them.

In an appendix the wave-lengths (on the International scale) of the enhanced lines of magnesium, as observed in the arc *in vacuo* in the course of the foregoing investigation, are brought together in a Table. For completeness additional lines observed by Lorensen and by Lyman are also included.

A. E. G.

1681. *Spectra given by Carbon and some of its Compounds.* W. M. Watts. (Phil. Mag. 28. pp. 117-128, July, 1914.)—A discussion is first given of previous work relating more particularly to the origin of the "Swan" spectrum. Experiments are then described in which the Swan spectrum was observed in the absence of oxygen, so far as it is possible to secure that condition. Observations with either the arc or spark in specially pure liquids showed that the Swan spectrum was produced in all the liquids used: heptane, hexane, octane, carbon tetrachloride, and chlorobenzene. On account of the rapid separation of carbon, only a few seconds were available for observation, and, consequently photographs could not be obtained. A summary is given of wave-length measurements of the chief lines of the band-spectra of carbon and some of its compounds. The results of the experiments, taken in conjunction

with those obtained by other investigators, lead to the conclusion that the Swan spectrum is due to carbon-vapour only. A study of Thomson's results shows that the Swan spectrum is given by the negatively-charged carbon atom, and not by either CO or CO₂. The Swan spectrum is given by CO at atmospheric pressure, but not by CO₂. In CO as the pressure is reduced the Swan spectrum dies away, and at low pressures is completely replaced by the second spectrum. This indicates that CO contains something not present in CO₂, but that this something gets smaller in amount as the pressure is reduced. Now Thomson finds that both carbon monoxide and carbon dioxide contain C++, O++, C+, O+, CO₂+, and CO+, whereas carbon monoxide alone contains C—. Further, he shows that such negatively charged atoms ought to be, and are, less numerous when the discharge has difficulty in passing, *i.e.* at low pressures. A. W.

1682. Zeeman-effect of Neon Lines. T. Takamine and K. Yamada. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 277-290, May, 1914.)—In these experiments absolute determinations of the strength of the magnetic fields were not attempted, but the separations of the lines under investigation were compared with the separation of a standard line of which the amount of separation is known for given field strengths. For such a spectrum as that of neon, which has a large number of bright lines in a comparatively narrow region between the yellow and red, it is convenient to use a horizontal echelon, as employed by Zeeman in his study of the dissymetry of the Zeeman-effect of the Hg line $\lambda 5790$. But the use of a Fabry-Perot interferometer is desirable on account of the smallness of the probable errors in the result. Applying both methods, two photographs were taken simultaneously for each stage of the strength of the magnetic field. The experiments were confined to the transverse Zeeman-effect. The separation of 28 neon lines was investigated for field strengths up to about 18,000 gauss. Most of the results agree with the previous work of Lohmann [Abstract No. 247 (1907)], but for some lines the results were not in good agreement, necessitating a change of the types assigned by Runge. Besides the lines investigated by Lohmann seven new lines were photographed and measured; these are given below :—

λ .	Separation.	Type.	λ .	Separation.	Type.
7082.65	9	$a/2$	5689.96	9	$a/2$
6929.78	9	$a/10$	5562.90	8	$a/8$
5820.29	8	a	5880.90	9	$a/6$
5764.55	8	$a/8$			

The regularity in the constant frequency-difference between many red lines is accompanied at the same time by regularity in the separations and intensity distributions of the magnetically separated lines. A. W.

1683. Radiation of Gas Molecules excited by Light. R. W. Wood. (Phys. Soc., Proc. 26. pp. 185-211, June, 1914. First Guthrie Lecture, delivered Feb. 27, 1914.)—Deals generally with the subject of resonance radiation, briefly summarising the results of the lecturer's recent work. L. H. W.

1684. Luminescence of Kunzite. E. L. Nichols and H. L. Howes. (Phys. Rev. 4. Ser. 2. pp. 18-27, July, 1914.)—The authors have investigated the fluorescence, absorption, and phosphorescence of two samples of kunzite, VOL. XVII.—A.—1914.

one in pink or rose-lilac crystals and the other in crystals almost colourless but with a suspicion of green or aquamarine tint [see Pochettino, Abstracts Nos. 875 (1910), 881 (1911)]. The red fluorescence band lying between 0.7μ and 0.5μ has a curve of distribution of intensities almost symmetrical about a crest at 0.59μ , but somewhat steeper towards the violet. The blue fluorescence band lies between 0.49μ and 0.40μ , with a crest at approximately 0.482μ . When the red bands of the two varieties, under cathodic excitation, are equally bright, the blue band of the white kunzite is 2.88 times as intense as that of the pink form. The absorption bands were also measured. The phosphorescence of kunzite exhibits various peculiarities. While it is of comparatively long duration, being easily discernible for several minutes after adequate excitation, decay is at first of extraordinary rapidity, so that measurable brightness remains only in cases where the initial intensity of excitation is very great; the law of decay was studied. Unlike many other phosphorescent substances, kunzite is comparatively inactive to photo-excitation, possibly owing to its transparency even in the absorption band. Like most, if not all, substances with protracted phosphorescence, kunzite requires an appreciable time to reach its maximum of excitation; under cathodic bombardment saturation is attained after a few seconds.

The investigator did not take into account the important feature of polarisation.
T. H. P.

1685. Luminescence. E. H. Farnau. (*Le Radium*, 2, pp. 168-176, June, 1914.)—Observations on the luminescence produced in certain salts by various agents have been made. The results obtained together with those of other observers are tabulated, and certain conclusions drawn from them as to the origin of the luminescence [see Abstract No. 478 (1914)]. In the author's observations colour photography was made use of to record the quality of the luminescence. Observations were also made on the change of colour of a number of substances when compressed. This change of colour was shown, in certain cases at least, to be due to simple agglomeration and not to the formation of allotropic modifications.
F. J. H.

1686. End Product of Thorium Family. R. W. Lawson. (*Nature*, 98, p. 479, July 9, 1914.)—Recent conclusions appear to show that the end products of all the radio-active families ought to be isotopic, or chemically identical, with lead. While there is good evidence for this in the case of the uranium family there is little in the case of thorium. From an investigation of the lead-content of several thorites and orangites, rich in Th, the author deduces that the end product of the known thorium family, viz. ThE, must be unstable with a period about 6×10^5 years.
E. M.

1687. Radio-activity and Atomic Numbers. A van den Broek. (*Nature*, 98, p. 480, July 9, 1914.)—Let Th_T , Ra_T , Ac_T be the periods of half change of corresponding members of the thorium, radium, and actinium family respectively, M the atomic number, $M(Pb)$ that of lead (and its isotopes) and c a constant (± 4.5); then for all substances emitting α -rays the following empirical relation is shown to hold approximately: $Th_T = \sqrt{Ra_T \cdot Ac_T / c^{M - M(Pb)}}$.
E. M.

1688. Radio-activity of Rocks of the Kolar Goldfields. H. E. Watson and G. Pal. (*Phil. Mag.* 28, pp. 44-51, July, 1914.)—The distribution of radium in five of the great mines is uniform, the amount of Ra per gm. of rock ranging from 14 to 84, in units of 10^{-14} gm. The quantity of Ra does not vary greatly with the Au-content.
L. H. W.

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HEAT.

1689. *Specific Heats of Liquids at Various Constant Pressures and Various Temperatures.* II. **S. Lussana.** (N. Cimento, 7. Ser. 6. pp. 804-812, May, 1914.)—Further measurements on ether at higher temperatures than those previously employed [see Abstract No. 89 (1918)] show that, as with ethyl and amyl alcohols, the diminution of c_p as the pressure rises, tends to become lower at the higher temperatures and pressures; at a sufficiently high pressure the variation of c_p changes its sign. The value of $c_p : c_v$, or γ , diminishes as the temperature and pressure rise. If the external work effected in liquids during heating be neglected and the difference between the two specific heats be attributed solely to the internal work, these results, in conjunction with the variations of the coefficient of dilatation at constant pressure with the pressure and temperature would show that the amount of internal work necessary during heating diminishes with increase of the pressure. The conclusion is drawn that the diminution of the distance between the molecules of liquids, which is naturally accompanied by restriction of the liberty of movement of the molecules, carries with it a diminution in the value of γ , and hence tends to cause the heat consumed during heating to aid the molecular energy. T. H. P.

1690. *Ratio of the Specific Heats of Gases.* **H. N. Mercer.** (Phys. Soc., Proc. 26. pp. 155-168; Discussion, p. 164, April, 1914.)—The main object of the experiments was to test the accuracy with which the ratio of the specific heats could be measured, using small quantities of the gas, with the ultimate view of experiments on the variation of the ratio with temperature. The method employed was that of Lummer and Pringsheim, in which the instantaneous fall of temperature corresponding to a given rapid fall of pressure is observed with a Pt thermometer of very fine wire. The values of the specific heat at constant pressure, calculated from the experiments, for air, hydrogen, carbon dioxide, and nitrous oxide are respectively 0.2408, 8.4704, 0.2000, 0.2185. These are in good agreement with direct calorimetric determinations. J. J. S.

1691. *Specific Heats and Principle of Similitude.* **R. C. Tolman.** (Phys. Rev. 4. Ser. 2. pp. 145-153, Aug., 1914.)—The author has already presented a number of derivations in different fields of physical science, all based on a single postulate called the principle of similitude, viz. "The fundamental entities of which the physical universe is constructed are of such a nature that from them a miniature universe could be constructed exactly similar in every respect to the present universe." In the present paper this same principle is used in deriving a formula for the specific heat of homogeneous isotropic elastic substances. It is found that the formula thus obtained for specific heat agrees with that of Debye for the specific heat of solids and liquids at low temperatures. But in the proof here given, it is *not* necessary to make use of any of the various forms of quantum theory. [See Abstracts Nos. 446 (1918) and 1195 (1914).] E. H. B.

1692. *The Lost Pressure in Gaseous Explosions.* **W. M. Thornton.** (Phil. Mag. 28. pp. 18-29, July, 1914.)—The total action in a gaseous explosion. VOL. XVII.—A.—1914.

sion is a multiple of that occurring in the formation of a single molecule. Consideration of the case of a diatomic gas gives the value 0.5 for the ratio of translational energies before and after formation. Experiment shows that this ratio varies in a definite manner and that the mean of its values over the working range in coal-gas and in many other mixtures giving perfect combustion also approaches 0.5. The suggestion is made that the "suppressed heat" in gaseous explosions may be explained by the influence of forces of cohesion which come into action at the moment of "contact" of two combining atoms. It would explain: (1) the loss of pressure; (2) the variation of the efficiency of combustion with strength of mixture; (3) the shape of the maximum pressure-percentage curves; (4) the differences between the explosion efficiency of gases having different limits of inflammability; (5) the influence of initial compression in raising efficiency of explosion, as a consequence of the limiting shape of the efficiency curves. After explosion the molecular translational energy of the products of combustion in a closed vessel would fall more slowly than in simple cooling of a hot gas in which equipartition is already established. This would have the same influence on the pressure as would after-burning, and may be the cause, at least in part, of the maintained pressure observed by Clerk in rich mixtures—in which it is shown the pressure efficiency should be the lowest—and of the prolonged radiation observed by B. Hopkinson after the flame stage has ceased.

T. H. P.

1693. *Trouton's Rule*. C. Sonaglia. (N. Cimento, 7. Ser. 6. pp. 821-828, May, 1914.)—Cederberg's objection to Nernst's equation (Zeitschr. physikal. Chem. 77. pp. 498-509, 1911), on the ground that it contains no constants relative to the particular compound, is invalid since the boiling-point enters into the equation. Cederberg claims for his own formula that it contains no empirical constants; since, however, it is derived by combining other relations with van der Waals' equation and the values of a are not the same but different for different compounds, this claim is open to criticism.

The author has investigated the values of Trouton's constant for ethyl and propyl formates, methyl and ethyl acetates, acetone, methyl ethyl ketone, diethyl ketone and dipropyl ketone at various temperatures which exactly correspond. Use is made of Nernst's formula,

$$\lambda = (\lambda_0 + 8.5T - \epsilon T^2) (1 - p/\pi_0),$$

in which ϵ is a constant and λ_0 the latent heat of evaporation at absolute zero. Accurate measurements of λ at two different temperatures give the values of λ_0 and ϵ , and hence the value of λ at any other temperature, so long as p is small compared with the critical pressure, π_0 . For reduced temperatures equal to or greater than 0.5 this condition is not satisfied, and in these cases p was calculated by means of Nernst's formula,

$$\log p = \lambda_0/4.571 T + 1.75 \log T - \epsilon T/4.571 + C.$$

The results show that the values of Trouton's constant for the esters become equal at a reduced temperature of about 0.5, whilst at lower temperatures marked variations occur. Nernst's observation that the values at the boiling-point increase with rise of temperature is not confirmed for the values at corresponding temperatures. On the other hand, the curves representing the variation of Trouton's constant with temperature for the last three ketones are similar but do not meet; the behaviour of acetone is complicated by the tendency of its molecules to associate.

T. H. P.

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1694. *Exact Method for calculating Vapour Pressure.* I. W. Cederberg. (Phys. Zeitschr. 15. pp. 697-705, July 15, 1914.)—The author has investigated the dependence on the temperature of the factor a of van der Waals' vapour-pressure equation, $\log (\pi_0/p) = a(3_0/T - 1)$, and has deduced the simple exponential formula, $a = a \cdot \beta^{(T/3_0 - \gamma)}$, where a represents the minimal value of a , β a constant, and γ the reduced minimum temperature. Combination of this expression with the van der Waals' equation yields a vapour-pressure formula, which allows of the complete representation of the total vapour-pressure curve of any substance. Application of this combined formula to various compounds gives good results, those obtained with water, for example, being in excellent agreement with the latest experimental data from the lowest temperatures to the critical point. Two of the constants in this expression seem to be independent of the nature of the substance, and on this basis an approximation formula is deduced which contains only physically well-defined magnitudes and yields good results, as is shown by applying it to the case of water between 100° and 180°. T. H. P.

1695. *The Partition of Energy.* J. D. van der Waals, Jr. (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 1082-1088, May 29, 1914.)—The author corrects, by the introduction of new assumptions, the formula for the dissociation equilibrium of a diatomic gas given in his previous communication [Abstract No. 284 (1914)]. He there shows that Planck's later supposition concerning the existence of a zero-point energy leads to the conclusion that the entropy of a number of particles does not change at the absolute zero-point when they pass from a binding in which they can vibrate with a definite period into another combined state in which they have another period. The simple assumption for a linear vibrator that, besides vibrations with frequency ν , rotations occur with a frequency $\nu' = h/2\pi^2 M$, then leads directly to Nernst's heat theorem as formulated by Planck with a finite value of the entropy for $T = 0$, in place of the value $-\infty$ of the older theory. The author points out that the infinite entropy difference would evidently be evaded only in two ways: (1) By assuming a finite number of distributions of the points of velocity also at high temperature, and (2) by assuming that there are infinitely many also at $T = 0$. The former hypothesis is that of the energy quanta, the second that of the zero-point energy. Each supposition leads to a finite relation of the number of possible distributions at $T = 0$ and at $T > 0$, and hence to a finite entropy difference. Investigation of the energy distribution at higher temperature, assuming that a number of molecules will possess an energy $< \nu h$, and that for them every value of the energy is equally probable, leads to the conclusion that Planck's zero-point energy hypothesis can only be reconciled with the thermodynamic law of the equilibrium-change when the probability function shows a discontinuity at $\epsilon = \nu h$, of entirely the same nature as had already been assumed by Planck. G. W. DE T.

SOUND.

1696. *Combinational Vibrations maintained by Two Simple Harmonic Forces.* C. V. Raman. (Indian Assoc. for Cultivation of Science, Bull. No. 11. pp. 1-24, 1914.)—The author previously dealt with a new class of forced oscillations maintained by periodic variations of a spring, of which the longitudinal mode of Melde's experiments is a specific case. It was thus shown that a simple harmonic force (due to a fork) acting longitudinally on a stretched string could maintain its vibrations when the frequency of the string's free oscillations in any given mode were nearly equal to any integral multiple of half the frequency of the fork [see Abstract No. 200 (1918)]. From the photographs of the above vibrations and the mathematical discussion, it became clear that a very important part in the maintenance of the motion is played by certain subsidiary components introduced into it under the action of the variable spring. It was shown that the principal component of the maintained vibration, together with the subsidiary motions thus introduced, could be arranged in the form of a Fourier series, the difference of frequency between the successive terms being that of the variable spring itself. This suggested the present work, in which a horizontal stretched string had its extremities attached to the prongs of two forks placed vertically with their directions of vibration parallel to each other and to the length of the string. Thus, neither fork tends directly to displace the string from its equilibrium position, but varies its tension, so the string remains undisturbed so far as transverse movement is concerned, except when the frequency of free oscillation of the string is adjusted so as to coincide more or less accurately with certain values termed "resonance frequencies." Certain of the resonance frequencies should obviously be multiples of half the frequency of one or other of the forks by itself (say $rN_1/2$ or $sN_2/2$, where N_1 and N_2 are the frequencies of the forks and r and s integers). But, besides the resonances of this kind, the author finds a large number of other cases of vigorous maintenance which have evidently to be ascribed to the joint action of the two forks on the string. Their frequencies may be denoted by $(rN_1/2) \pm (sN_2/2)$, where the positive sign applies to summational resonances and the negative sign to differential resonances.

The paper contains a mathematical treatment of this mode of maintenance, full details of the method of photographing the vibrations, and 12 clear reproductions of them. E. H. B.

1697. *Motion in a Periodic Field of Force.* C. V. Raman. (Indian Assoc. for Cultivation of Science, Bull. No. 11. pp. 25-42, 1914.)—Deals with the different speeds at which an electromagnetic phonic wheel or synchronous motor may be run or oscillated. Using a fork interrupter, it was found that the frequency of vibration of the armature wheel might be equal to $1/2$, $1/8$, $1/4$, $1/5$, or $1/6$ that of the fork (which was about 24 per sec.). The paper includes the mathematical theory, and a series of fine photographs exhibiting the relations of the frequencies of the armature and fork, or of the speed of the armature when continuously run under various excitations. E. H. B.

1698. *Musical Scale.* A. Vaucher. (Archives des Sciences, 88. pp. 53-67, July, 1914.)—Additional notes on the mathematical theory of the musical scale discussing specially the functions of temperaments. [See Abstract No. 800 (1914).] E. H. B.

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ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1699. Method for e/m from Thermionic Currents. S. Dushman. (Phys. Rev. 4. Ser. 2. pp. 121-184, Aug., 1914. Phys. Zeitschr. 15. pp. 681-685, July 15, 1914.)—An experimental research whose chief results are as follows :—
 (1) The space charge formula developed by I. Langmuir for the thermionic current from a heated filament to a coaxial cylindrical anode has been tested experimentally over a range of voltages from 85 to 140, for the case of a tungsten filament in a concentric molybdenum cylinder. (2) The results obtained are in good agreement with this formula, and indicate that the method ought to prove a very accurate one for the determination of e/m . (3) The observations obtained on the effect of gases on the thermionic currents are also found to be in accord with Langmuir's surface film theory, and justify the conclusion that there exists a pure electron emission from heated metals which is a function of the temperature only, and is not a secondary effect due to presence of gases as assumed by some investigators. [See Abstract No. 725 (1914).]
 E. H. B.

1700. Potential Theory. J. G. Leathem. (Roy. Irish Acad., Proc. 82. pp. 31-50, Sept., 1914.)—An analytical treatment of doublet distributions in the theory of potential.
 E. H. B.

1701. Propagation of Electric Waves on a Cylindrical Conductor. A. Signorini. (Accad. Lincei, Atti, 23. pp. 948-949, June 21, 1914.)—Mathematical.

1702. Electrification of Water by Splashing and Spraying. J. J. Nolan. (Roy. Soc., Proc. Ser. A. 90. pp. 531-548, Aug. 1, 1914.)—The object of the work is to establish a connection between the charge produced on a sprayed liquid and the extent to which it has been broken up. The liquid used is distilled water, and two methods are described for breaking it up in contact with the air : (1) by splashing against an air-blast, (2) by spraying. In the first method drops are allowed to fall into a strong horizontal air current. Each drop is shattered by the blast into a number of varying size, and a rough sorting out is effected as the bigger drops are carried further aside by the blast. The drops chiefly used are the fine ones which enter a measuring vessel placed directly under the dropper, as these are fairly uniform in size. Variations in size can be obtained by altering the height of the dropper or the strength of the air-blast. In the second method an ordinary scent spray is used to form the drops. Measurements are made of the charge carried to the receiving vessel, the volume of water, and the number of drops which enter it (giving the mean size of the drops). It is found that the charge, E , per cm^3 of water increases with a decrease in the radius r of the drop. $E = k/r$ where k is a constant. This result is explained simply, on the assumption that the charge on the water is proportional to the area of new water surface created when the drops are formed. Both methods give good agreement in the value of the constant. The air drawn from the sprayer—
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was examined to find how the negative charge is carried. A detailed account will be given later, but in a *résumé* the author states that the air was found to contain a number of ions of both signs (excess of negative), ranging in mobility from the large ion found by Langevin to the ordinary atmospheric ion. It is probable that the excess of negative charge in the air is present mainly as small ions. T. H.

1703. *Theory of Electrical Dispersion into the Free Atmosphere, with a Discussion of the Theory of the Gerdien Apparatus.* W. F. G. Swann. (Terrestrial Magnetism, 19. pp. 81-92, June, 1914.)—Riecke has shown that if a charged sphere is placed in a stream of air it loses its charge at a rate given by $-dQ/dt = 4\pi Qnev$, where Q is the charge on the sphere, n the number per cm^3 of ions of opposite sign to the charge Q , v the specific velocity of these ions, and e the ionic charge. The present author brings forward a proof of this formula for the more general case where the charged body is not necessarily a sphere and where the air does not flow in parallel streamlines with uniform velocity. Applying this equation to the Gerdien conductivity apparatus, he finds that the accepted formula by which conductivities are calculated with this apparatus is incorrect, and leads to results 20 % too high. Experimental evidence is adduced in support of this result. A theory of the collection of radio-active deposit by a charged conductor is also given. J. S. DI.

1704. *Notes on the Atmospheric Electrical Potential Gradient in the Industrial Districts around Leeds.* D. W. Steuart and I. Jørgensen. (Roy. Soc. Edinburgh, Proc. 84. pp. 202-207, 1913-1914.)—The paper gives the results of experiments made to determine the effect which smoke from chimneys has on the potential gradient. Positions on the lee of factory chimneys were taken up, and large positive gradients were invariably found when the smoke passed over the spot chosen. Readings of over 800 volts/m. were commonly obtained at over 1 mile from large chimneys. A position near a railway line was also taken up, and very striking results obtained when the smoke from passing locomotives blew over the position. It is concluded that in these cases of combustion for ordinary commercial purposes many ions are formed, and that most of these are of the positive sign. J. S. DI.

1705. *Protective Range of Lightning Rods.* J. Larmor and J. S. B. Larmor. (Roy. Soc., Proc. Ser. A. 90. pp. 812-818, May 28, 1914.)—Electric discharge in a gas is a rupture along a line of force, and not over a surface. The initial rupture is to be expected at a place of maximum force, and spreads in both directions along the line of force through that point. In the case of a lightning rod the discharge would start at the summit of the rod, the place of most intense strain, and strike away from the rod. Once a line of disruptive discharge is established, the neighbourhood of a lightning rod can have little effect, and a simple mathematical investigation shows that a thin isolated rod will draw the discharge hardly at all unless in the region around its summit, and that the modification in the field due to a thin rod is negligible along its sides unless close to it. It is the building carrying the rod which modifies the field and directs discharge to its own upper parts, which, therefore, need protection by conductors adequate to draw off this discharge to earth; and vertical rods, joining together, if need be, lower down, but rising from the corners of the structure to a height which need not exceed about half its breadth, will lift up the field of concentrated electric force VOL. XVII.—A.—1914.

from the region directly above the building to the region above their summits, and will so take the discharge. The rods may rise from an earth-connected network spread over the roof, but unless the meshes are fine enough to approximate to a complete metallic covering, it is questionable whether it would in itself protect a building from a discharge striking down upon it. A spread of connected metallic points some height above the building would appear to be more effective, and might even by themselves suffice to take up and guide away any likely stroke. In fact, if we neglect the discharge from the rods into the field, their effect is merely to provide the easiest and most probable path for such discharges as may be attracted by the structure. The discharge from the pointed extremities of the rods adds, of course, to the protective effect by slowly, but continuously, reducing the strain in their neighbourhood, and therefore the liability to disruptive discharge.

G. W. DE T.

DISCHARGE AND OSCILLATIONS.

1706. *Positive Ionisation from Heated Platinum.* C. Sheard. (Phil. Mag. 28. pp. 170-187, Aug., 1914.)—This paper presents the results of some investigations made as to the dependence of the positive ionisation from heated Pt-wires upon (1) temporary heatings of the wire when earthed and at temperatures higher than a chosen lower temperature at which the positive thermionic current was subsequently measured; (2) temporary heatings of the wire under negative potential and at such temperatures as to give small negative currents, the positive emission being investigated at an arbitrary, chosen temperature; and (3) heating the wire in a Bunsen flame and in CO_2 , and also rewashing in nitric acid. Results show that there is an increase of positive thermionic currents produced in high vacua (a) by heating a wire under zero potential at higher temperatures than at which the ionisation is subsequently measured, and (b) by heating the wire under negative potential at such temperatures as to discharge negative electricity. A detailed examination is made of the positive currents produced by method (a) cited above in dry air at atmospheric pressure. Maximum effects are obtained after heating at 654° and 756° when tested at 628° C. The intimate connection between the decrease of positive thermions produced at temperatures above 756° C. and the liberation of electrons is pointed out, and a general theory given to account for the experimental results obtained. Similar results are obtained by heating the wire in the reducing portion of the Bunsen flame. The rôle played by hydrogen in producing an increased positive emission is discussed, and the theory advanced that hydrogen, through its affinity for electrons, accelerates the production of positive ions by (a) inhibiting recombination of positive and negative ions, and (b) by removal of electrons. A decreased rather than increased positive ionisation is occasioned by heating in CO_2 : a possible explanation is offered. An investigation of the decay with time of the positive currents at different temperatures shows the existence of at least two sources of ions; the first gives decay effects according to an exponential law, the second shows an increase to a maximum followed by subsequent decay with time. [See also Abstract No. 184 (1914).]

A. E. G.

1707. *Emission of Electricity from Various Substances at High Temperatures.* G. W. C. Kaye and W. F. Higgins. (Roy. Soc., Proc. Ser. A. 90. pp. 480-487, July 20, 1914.)—Experiments have been conducted at temperatures from 2000° to 2500° C. within a carbon-tube furnace at atmospheric

pressure. The procedure adopted is to measure the electrical emission from a particular substance when it is heated in a graphite crucible, and then to repeat the experiment, under the same conditions, with the same or a similar crucible when empty. As the crucible, in some cases, absorbed the fused material and thus became permanently contaminated, the reverse order was, as a rule, the more convenient. For each material tested a new crucible was substituted. Under these conditions the electrical emissions, in the absence of any applied potential, have been measured for a number of substances on their introduction into the furnace. Among the substances tested were the alkaline earths (BaO , CaO , SrO , MgO), soda-lime, alumina (Al_2O_3), oxide of iron (Fe_2O_3), silica (sand), and the metals Sn, Cu, Al, Fe, and brass. Usually the substance was in a state of powder.

In most instances, the effect of suddenly introducing the various substances into the hot furnace was a little violent. A puff of smoke or flame occasionally shot from the furnace mouth, evidence of, violent boiling being plainly recognisable in some cases. The absorption of the white light from the incandescent central region of the furnace by the vapour in the cooler parts of the tube imparted, in some instances, a striking colouration to the emitted light. Some of these colours were obviously complementary in tint to those usually associated with thermal excitation. For instance, CaO gave a yellow-green colour, BaO a beautiful salmon-pink, and SrO an intense green; Al gave a brilliant yellow, and Al_2O_3 a beautiful green. During their rapid volatilisation the substances gave out large amounts of electricity, which, with one exception, was negative in sign. For example, barium oxide and alumina generated negative currents of the order of 4 amps. per cm^2 , boiling tin about 2 amps. per cm^2 , and boiling iron about 1 amp. per cm^2 . Boiling brass, on the contrary, produced a positive current of about 0.5 amp. per cm^2 .

The results have interest in connection with the problems of solar magnetism.

A. E. G.

1708. *Ionisation produced by Certain Substances when Heated on a Nernst Filament.* F. Horton. (Cambridge Phil. Soc., Proc. 17. No. 5. pp. 414-424, May 5, 1914.)—W. Wilson failed to detect any positive ionisation from aluminium phosphate heated on a Nernst filament, although the positive emission from this salt when heated upon Pt has been investigated by several experimenters. He therefore concluded that "the leak observed when the salt is heated on Pt is either mainly a leak from the Pt itself, or the latter plays an important rôle in its production" [see Abstract No. 1206 (1911)]. The author has recently been studying the thermal ionisation produced by Nernst filaments and, having the apparatus at hand, it was thought desirable to test the views as to the origin of the ionisation from glowing solids by ascertaining (a) whether lime heated upon a Nernst filament gives a negative emission comparable with that obtained when it is heated upon platinum, and (b) whether the positive emission from a glowing Nernst filament is increased by placing sodium phosphate upon it. It has already been shown that sodium phosphate heated upon Pt gives a large positive ionisation which is more permanent than that given by aluminium phosphate. The discharge tube used in these experiments is similar to that previously described, the only difference being that the two parallel Pt plates which form the anode are rather further apart in the present apparatus. These plates are situated vertically 1.5 cm. apart, at the centre of the small bulb which forms the discharge tube. The Nernst filament when in position is parallel to the plates and midway between. It can be heated by an alternating current led in

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through stout Pt-wires, and the filament and its leads can easily be removed from, or replaced in, the bulb.

A Nernst filament is heated in a good vacuum (the residual gas having a pressure of 0.0001 mm.) until the negative current obtained from it under a p.d. of 214 volts has become fairly constant. The curve given shows that at temperatures above about 1500° C. the thermionic current increases directly with the temperature, and not in the exponential manner usually obtained with substances heated at lower temperatures. A glowing lime-covered filament is placed in the apparatus and the air-pressure reduced. It is at once obvious that under these conditions the lime gives an enormous negative emission, for, as the pressure is reduced to a few mm. a brilliant glow appears in the discharge tube, without the application of any e.m.f. except that of the heating circuit. One of the Pt-wire leads to the filament was kept earthed, and from the appearance of the discharge it was seen that the bare end of this wire near the filament was acting as an anode. By lowering the temperature of the cathode the luminous discharge could be stopped, but at the lower temperature it could be started again by earthing the parallel-plate anodes of the discharge tube, by touching with the finger. The results described are sufficient to show clearly that the large negative emission obtained from lime heated on Pt cannot be attributed to the metal with which it is in contact. The form of the current-pressure curve for the positive emission from a Nernst filament is exactly similar to that given by Pt. The filament is next covered, except for about 1 mm. at each end, with a layer of pure sodium phosphate, by evaporating a water solution of that salt upon it a few drops at a time. It is then fitted into the discharge tube and the positive emission re-tested. The effect of placing sodium phosphate upon the filament is to reduce the pressure of max. emission very considerably, so that at pressures of a few mm. there is a very much greater ionisation from the phosphate-covered anode than from the filament alone. The ionisation at all pressures is increased by the presence of the sodium salt, but the increase is most marked at pressures of a few mm. The form of the current-pressure curve for a clean filament is similar to that given by a Pt-strip which has been heated for a long time. In the latter case there are strong reasons for believing that the ionisation is due to gas evolved from the heated Pt, and it would appear probable that the ionisation from the Nernst filament is due to a similar cause. Reasons are given to show that the shape of the curves given by pure Pt and by a clean Nernst filament can be explained by ionisation by collisions coming in at certain pressures. The effect of sodium phosphate is probably twofold: (1) it increases the formation of positive ions at the surface of the anode, and (2) it changes the nature of the gaseous material through which the discharge takes place.

A. E. G.

1709. Disintegration of Gaseous Ion Clusters in Electric Field. R. D. Kleeman. (Phil. Mag. 27. pp. 917-942, June, 1914.)—The equilibrium of free ions and clusters under the laws of thermodynamics and mass action simply, and its bearing on the velocity of ions has been dealt with by the author [Abstract No. 748 (1912)]. The disintegration may be affected by an electric field, (1) by increasing the impact between ion clusters and molecules, (2) by completing the separation of an ion from a cluster of neutral molecules, separated by collision which, but for the field, would recombine. Negative ion clusters are experimentally found to be disintegrated through bombardment by neutral molecules, and so, for equilibrium, the free negative ions must continually form clusters. The average life of a negative ion

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cluster in air at atmospheric pressure, and not specially dried, is calculated to be 4.2×10^{-7} sec., and that of the ion 1.1×10^{-6} sec. In CO, results of the same order are found. The velocity of a negative ion cluster is found to be greater than if proportional to an electric field of such magnitude as readily to produce ionisation by collision. For air not specially dried X/p must be not less than 178, where X is the electric force per cm., and p the barometric pressure. Fields of such order cause disintegration through the velocity given to the clusters, the effect increasing with the strength of field as shown by experimental curves. For air, CO, and hydrogen, the critical values of X/p are about 820, 640, and 58 respectively. It may happen that for a certain gas pressure and field intensity the chance of a negative cluster breaking up in passing over a given distance is less than the chance of a positive ion producing a new ion by collision. Kinks in the curves afford some indication of the number of kinds of clusters present, and the majority of negative clusters in a gas appear to be of one kind only. The kinks also give the mean free path of disintegration of a cluster. A theoretical expression is obtained for what should be the length if the path of the velocity of the cluster were proportional to the strength of the field, and an expression for the life of an ion cluster is deduced from this.

G. W. DE T.

1710. *Ionisation of Gases by Collision and the Ionising Potential for Positive Ions and Negative Corpuscles.* W. I. Pawlow. (Roy. Soc., Proc. Ser. A. 90. pp. 898-411, July 20, 1914.)—The method first used by Lenard for measuring the ionising potential for negative corpuscles is used here for both negative and positive particles. The particles are first given a certain velocity before entering the test chamber where they are submitted to a retarding field larger than the accelerating field. If no ionisation by collision occurs, the receiving electrode will receive no charge. The charge obtained by this receiving electrode is plotted against the accelerating field, and, as is well known for negative corpuscles, a linear relation is found, the line cutting the axis at a definite field, e.g. 11 volts in the case of hydrogen. In the present experiments the negative particles are got from a hot Pt-strip, and positive particles from hot sodium phosphate. To make sure that the number of particles escaping from the Pt or from the sodium phosphate was not influenced by the field, a constant auxiliary field was used to extract them. For negative particles hydrogen and helium were investigated and ionisation potentials of 11 and 20 volts respectively were obtained, quite independently of the intensity of the source. For positive particles, hydrogen, oxygen, nitrogen, and helium were investigated. In all cases the intensity of emission has an influence. The relation between the charge obtained by the electrode and the accelerating field is not linear, and it is not easy to say definitely where it cuts the axis. For hydrogen, however, it cuts the axis at a point somewhere under 10 volts, showing that the ionisation potential is of the same order of magnitude as for negative particles. This value, though, varies with the intensity of emission—a fact which seems to point to a complicated velocity distribution of the positive particles. On investigation it was found that the negative particles have nearly all the same velocity, whilst the positive particles have their velocities distributed more widely. Thus, though this research shows that the energy required by a positive particle to ionise is of the same order as that for a negative particle, there are certain differences in the actual process. One more example of this is that a negative thermionic current about 10 times smaller than a positive one sometimes gives an ionisation 10 times larger with equal velocities of the carriers. A possible reason

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for this difference is that the collisions which result in the ionisation of a molecule of a gas occur much more often in the case of negative corpuscles than in the case of positive ions. This view is confirmed by Townsend's theory of ionisation by collision. J. R.

1711. *Photoelectric Phenomenon presented by Liquid Dielectrics.* L. Stramp. (Acad. Roy. de Belgique, Bull. pp. 45-62, 1914.)—Ultra-violet rays have a marked influence on the loss of an electric charge by liquid paraffin, light petroleum, shale oil, and Russian mineral oil, the discharge being accelerated to the greatest extent with liquid paraffin and petroleum positively charged, and with shale oil and Russian mineral oil carrying a negative charge. This effect is regarded, not as a result of ionisation of the air, but as a surface photoelectric phenomenon, since the velocity of discharge for either a positive or negative charge may be diminished or increased at will by mixing paraffin and shale oil. T. H. P

1712. *Theory of the Becquerel-effect. I. Photoelectric Investigations with Oxidised Copper Electrodes.* A. Goldmann and J. Brodsky. (Ann. d. Physik, 44. No. 6. pp. 849-900, July 8, 1914.)—The Becquerel-effect is a change of the potential of an electrode in an electrolyte due to light if the electrode is covered with a thin solid layer sensitive to light, or if the electrolyte contains a substance sensitive to light. The authors postulate that this effect is similar to the Hallwachs-effect and perform experiments to verify their view. The electrode used is oxidised copper. The method of experiment is as follows: The electrode in darkness is given a certain potential. Light falling on it causes this potential to change. An extra current is sent through the electrolytic cell to bring back the electrode to its original potential. This extra current is taken as a measure of the photoelectric current of the electrode at the original potential. Plotting the current-potential curve it is found that the current depends on the potential in the same way as for the photoelectric current in a vacuum, similar curves to those of Richardson and Compton being obtained. The current was found to be independent of the concentration of the electrolyte between the strengths of a $N/1$ and $N/20$ solution of common salt. It is independent of the salt used. In neutral solutions it is independent of chlorides, bromides, sulphates, and of nitrates of alkalis and earth alkalis. It is the same whether water or methyl alcohol is used as solvent, and it is not influenced by the dielectric constant of the surrounding medium. Temperature was found to have some influence, the current rising with the temperature. An effect which was named "solarisation" was observed, which is that by continuous exposure to light the current diminishes, and when the light is shut off there is a current in the opposite direction, which current sinks gradually to zero. Solarisation is removed to a very large extent by stirring the liquid, showing that it is an effect of the electrolyte as opposed to the main effect which is due solely to the sensitive electrode. When solarisation is removed by stirring, the current is proportional to the intensity of light. J. R.

1713. *Theory of the Becquerel-effect. II. Basis of a Photoelectric Theory of the Action.* A. Goldmann. (Ann. d. Physik, 44. No. 6. pp. 901-915, July 8, 1914.)—Goldmann and Brodsky [see preceding Abstract] have shown that there is great similarity between the Becquerel and Hallwachs effects. The former may be explained in a similar way to the latter by the liberation by light of electrons from the electrode. In the Becquerel-effect, however, the electrons must pass through a relatively strong field of a double layer at the

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surface of the electrode and emerge into a conducting medium instead of being caught by a surrounding electrode. In this surrounding medium they become slow-moving carriers of electricity. The thickness of the double layer is estimated to be of the order of 10^{-6} cm., whilst the mean free path of the electrons is of the order of 10^{-4} , so that most of them should get through the double layer. As they are all converted into slow-moving ions it is to be expected that the max. photoelectric current should set in when the retarding field has been reduced to zero. This is actually found to be the case. Solarisation [*loc. cit.*] can be explained by assuming that there are not enough positive carriers about to neutralise the electrons, so that the electrode to which the electrons are travelling attains a potential in a direction tending to produce a negative photoelectric current. After a long exposure this back effect may be fairly large, accounting for a kind of fatigue and detracting from the proportionality between the current and intensity of light unless when the electrolyte is being stirred. After the light is shut off the back effect will continue alone, and will gradually diminish to zero till all the negative carriers have been taken from the electrolyte. A discrepancy in this theory of the Becquerel-effect is that currents of the order of 10^{-4} amp. per cm. can be obtained, whilst with the same electrodes *in vacuo* the value is about 10^{-9} amp. The author suggests that this may be because *in vacuo* the double layer has a very large retarding field, whilst in the electrolyte it is reduced in some at present unknown manner. J. R.

1714. *Passage of Kathode Particles through Gases at Low Pressures.* L. W. McKechnan. (Phys. Rev. 4. Ser. 2. pp. 140-144, Aug., 1914.)—The object of the work was primarily to determine whether a very narrow pencil of kathode rays is scattered by traversing a high vacuum. An apparatus is described by means of which the rays can be made to pass through an anode, containing a brass tube 5 cm. long, 0.02 cm. internal diam., into a test chamber, 60 cm. long, terminated by another transverse tube serving as a photographic camera. The greater portion of these rays have a speed, determined by deflection in a magnetic field, between 2.7×10^9 and 8.0×10^9 cm./sec. At the lowest pressure used, 5×10^{-6} cm. of Hg, absence of scattering is shown by the fact that the shadow of an obstruction in the tube cast on the photographic plate is that geometrically obtainable by drawing straight lines enveloping the obstruction from a point in the discharge tube. An angle of scattering exceeding 80 seconds of arc could have been detected. Scattering becomes apparent at a pressure of gas in the chamber of 8×10^{-4} cm. of Hg, but even at 1.2×10^{-6} cm. the geometrical pattern on the plate, though faint and overlaid by the impression due to scattered radiation, was of the same size and as sharply defined as at lower pressures. The conclusion is, that at this pressure a considerable number of electrons must have free paths in excess of 60 cm. According to Franck and Hertz, slow kathode rays, for the case discussed, should have paths of 8.4 cm., according to Townsend 6 cm. This suggests that high-speed kathode rays must in many cases pass through the atom without measurable change in direction. Positive rays were shown to be much scattered at pressures which did not affect kathode rays. An attempt was made to deduce the law of scattering of kathode rays from the impression of scattered radiation on the plate. Reasons for failure and for the advisability of attacking the problem in another manner are given. T. H.

1715. *Attempts to produce the Rare Gases by Electric Discharge.* T. R. Merton. (Roy. Soc., Proc. Ser. A. 90. pp. 549-558, Aug. 1, 1914.)—The VOL. XVII.—A.—1914.

author has made attempts to produce the rare gases by the passage of an electric discharge in hydrogen by a method differing essentially from that employed by Collie and Patterson, or by Strutt [see Abstracts Nos. 1086 (1918), 1102 (1914)]. Although many experiments were made with electrodes of Al, Cu, Ni, Ag, Pt, and Pd, no traces whatever of the rare gases could be found so long as extreme precautions were taken for the exclusion of air. Argon found to be present in some experiments was shown to be due to a minute continuous leak of air, and the author suggests that the appearance of argon rather than neon might be used as an extremely delicate test for air leakage.

F. J. H.

1716. *Production of Rare Gases by Electric Discharges.* J. N. Collie. (Roy. Soc., Proc. Ser. A. 90. pp. 554-556, Aug. 1, 1914.)—Making use of the apparatus employed by Merton [see preceding Abstract], the author has examined the gases given off from metallic uranium by bombardment with kathode rays produced by a discharge in hydrogen. When a coil with a Pt break was used the residual gases after the removal of CO₂, water-vapour, and nitrogen (produced most probably from a nitride of uranium) were invariably neon, helium, and a minute trace of argon. The relatively small quantity of argon present makes it highly improbable that the gases were derived from a leak of air. The gases were not produced when a larger coil provided with a mercury break was used for the production of the kathode rays, neither could they be obtained from the Ur by heating.

Further experiments are in progress.

F. J. H.

1717. *Absorption of Gases in the Discharge Tube.* F. H. Newman. (Roy. Soc., Proc. Ser. A. 90. pp. 499-506, Aug. 1, 1914.)—Mey has shown that the liquid alloy of Na and K when used as kathode in a discharge tube absorbs nitrogen and hydrogen at a rate much greater than that of the absorption of gases by the walls of the tube [see Abstract No. 1488 (1908)]. It has also been shown by Stark that mercury placed near the kathode in a discharge tube absorbs oxygen. It is here shown that the liquid alloy of Na and K absorbs nitrogen and hydrogen when used as anode, though not to the same extent as when kathode. Also, if the discharge is passed between Al electrodes the alloy absorbs these gases. It is also shown that mercury absorbs oxygen when used as anode, but not to the same extent as when used as kathode. The absorption depends considerably on the pressure in the tube, increasing as the pressure diminishes, the quantity of electricity passing being the same. The quantity of electricity is measured in terms of the volume of hydrogen liberated in a voltameter. The alloy absorbs about 8 times the volume of gas liberated in the voltameter at a pressure of 0.8 mm. Hg, whilst at a pressure of 10 mm. the volume of N or H absorbed is only about 1.5 times the volume of hydrogen liberated in the voltameter. Similar amounts apply to the case of oxygen absorbed by mercury. An explanation of the absorption of gases is given, following the discovery of Strutt of a chemically active modification of nitrogen. It is shown that the absorption of nitrogen by the Na-K alloy causes a formation of nitrides of the metals by passing moist air over the alloy, and then into water, where the Nessler test for ammonia is applied. Evidence for this active state of nitrogen is given by passing nitrogen through a discharge between extra electrodes, and then over the alloy. The gas is then passed into water, where the Nessler test showed the presence of ammonia. When the nitrogen was not previously passed through a discharge tube no trace of ammonia was found. The larger

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absorption at the kathode than at the anode may thus be due to the fact that the electric force at the kathode is larger, and thus there is more active gas there. Another possible explanation of the large kathode absorption is, that it is the positive rays which are absorbed. J. R.

1718. Brush Discharge Phenomena produced by Continuous Potentials. S. P. Farwell. (Phys. Rev. 4. Ser. 2. pp. 81-89, July, 1914.)—With a large p.d. between a wire and neighbouring conductors, such as a similar and parallel wire, or a coaxial cylinder, the discharge phenomenon known as "corona" is likely to occur. For alternating p.d.'s this phenomenon has been extensively studied, but the corona produced by continuous potentials has not received so much attention. Watson [see Abstract No. 886 (1910)] has experimented on wires as small as 0.7 mm. and at pressures as low as 860 mm. Schaffers [Abstract No. 1716 (1918)] has worked with cylindrical fields, using wires as fine as 0.006 mm. and various sizes of tube, and has determined the critical voltage for visual corona at atmospheric pressure. The present paper deals with a study of the corona as produced by continuous potentials for wires from 0.087 mm. to 1.285 mm. diam. and tubes 8.50 cm. and 4.45 cm. in diam. The relation between the p.d. and the current between wire and tube has been studied for atmospheric pressure for the different sizes of wire; the critical voltage for visual corona has been obtained for pressures from somewhat above atmospheric down to 2.0 mm. of Hg, and the character of the discharge noted; the effect of variation of voltage for a constant low pressure has also been investigated. Special attention is paid to some of the phenomena observed at low pressures, to the influence of a short arc in series with the apparatus upon the character of the discharge, and to the increase of pressure in the tube due to the ionisation. Numerous photographs are reproduced. [See also Abstract No. 1595 (1914).] A. W.

1719. Effect of a Longitudinal Magnetic Field on Spark Potentials. R. F. Earhart. (Phys. Rev. 4. Ser. 2. pp. 185-189, Aug., 1914.)—A continuation of a former paper [see Abstract No. 1099 (1914)]. The author concludes that, using parallel plate electrodes, electric and magnetic fields parallel: (1) Spark potentials for pressures above the critical pressure are unaffected by the longitudinal magnetic field. (2) Those below the critical pressure are decreased by such a field. (3) When the pressure exceeds the critical value, the existence of the field requires a higher potential to maintain the discharge than if no field existed. (4) The variations noted in (3) are increased with increasing fields and become larger as the gas pressure is increased. T. H.

1720. Method of directly measuring the Time of Propagation of Electric Waves on the Surface of the Globe. H. Abraham, A. Dufour, and G. Ferrié. (Comptes Rendus, 159. pp. 88-40, July 6, 1914.)—The method employed is derived from that which in 1911 had enabled Claude, Drien-court, and Ferrié to ascertain between Paris and Bizerta that signals travelled with a speed comparable to that of light. It is in sum that of reciprocal strokes formerly utilised for the measurement of the speed of sound, but adapted to wireless telegraphy. A station A_1 sends the first signal to which A_2 responds by a second signal. At A_1 the time T_1 is noted which elapses between the departure of the first signal and the return of the second; and at A_2 is noted the time T_2 which has elapsed between the reception and emission of the same signals. It is clear that T_1 should be greater than T_2 , and that $T_1 - T_2$ represents the time of the passage to and fro. For the experi-

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ments photographic micro-galvanometers were used in connection with galena detectors. At the moment of passage of a train of waves the galvanometer receives a percussion which gives a sharp angle on the photographic trace. It is the instant of this percussion that it is essential to mark. For this purpose there is photographed on a band of sensitised paper, which is in continuous motion, the image of a fixed slit illuminated by instantaneous flashes at each oscillation of a tuning-fork. Besides the galvanometric trace there is inscribed thus on the photographic paper a series of transversal lines corresponding to definite periods between which interpolation is easy. The precision is necessarily limited by the uncertainty of the micrometric points and by the irregularities of the movement of the paper, but the mean of several inscriptions afford a precision of $1/100000$ sec. Musical sparks, as used between Paris and Washington for these observations, do not afford accuracy sufficient to mark the first constituting the signal at very long range, and the error may amount to the interval between two of the sparks. Series of trials were made between Paris and Toulon, Paris and Toul, and Paris and Washington. The conclusion is reached that wireless waves travel along the surface of the globe at an apparent speed slightly less than that of light.

E. O. W

1721. *Hertzian Wave Transmission along Helical Wires.* F. Bourcier. (Comptes Rendus, 158. pp. 1882-1884, June 22, 1914.)—Using a method of measurement due to Gutton [Abstract No. 1058 (1898)], the author finds the time of transmission along a helix to be always less than along a straight wire of equal length. In a closely wound helix the loss by reflection reduces the intensity to an amount too small to be measurable. When the axial length of the helix is gradually increased by increasing the distance between successive turns a minimum time of transmission is observed at a certain stage, depending on the dimensions of the helix. The intensity attains a value practically indistinguishable from the maximum long before the helix is completely transformed into a straight wire.

G. W. DE T.

1722. *Energy used by Transmitters of Small Wave-length.* G. Leimbach. (Jahrbuch d. Drahtlosen Telegraphie, 8. pp. 409-429, May, 1914.)—The purpose of the author's experiments was to see how far the energy taken up by small transmitters could be increased, the transmitters having dimensions of the same order as those of Hertz (wave-length < 2 m.). The oscillating energy (E) in such a system is $E = N\frac{1}{2}CV^2$, where N is the spark frequency. The amount of energy stored can be increased by (1) increase of capacity, (2) raising the voltage, and (3) increasing N . If C is increased the wave-length is altered, and if the wave-length is to be kept constant the inductance must be simultaneously reduced. Increasing the energy by increase of V leads to large damping in the spark-gap. The third possibility gives rise to arcing.

A form of sender used by the author consists of two parallel discs forming the condenser in between which the spark-gap is placed. The distance apart of the discs is adjustable, and small conical tubes mounted on the discs form the antenna. The transmitter was excited by a small spark coil whose primary energy was kept constant. The receiver was a resonant circuit with contact detector and mirror galvanometer. With a spark-length of $\frac{1}{10}$ mm. the capacity was varied between 10 and 500 cm., the primary energy remaining constant. As the capacity was decreased the galvanometer deflections rose, since with constant charging current the number

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of discharges varied inversely with C. This held until the capacity of the condenser was smaller than that of the spark-gap and the antenna. From the experiments the author deduces:—(1) The Hertzian type of sender is specially suitable for senders of small wave-length. (2) The energy radiated is principally determined by the capacity. (8) Condensers parallel to the spark-gap and also spark-gaps having a high capacity are useless, and waste energy.

The second part of the investigation was directed to the influence of the increase of V. The table below reproduces the results:—

Spark length, mm.	0.1	0.2	0.8	0.4	0.5	0.6	0.8	1.1	1.5
Galv. deflection	2.5	8	11	18	18	15.5	17.5	20	21

From this table it will be seen that the received energy initially rises approximately as the square of the spark-length. A Schloemilch detector was used for this test. The falling-off at greater spark-lengths is explained by the reduction in N with constant current as the potential increases. The substitution of a contact detector gives quite different results:—

Spark-length, mm.	0.1	0.8	0.5	0.7
Galv. deflection	100	54	84	26

The explanation of this result lies in the fact that at the small spark-lengths the charging current being constant, the spark frequency is higher and the type of detector used integrates the individual impulses. The resultant effect is that received energy due to N rises more rapidly than the energy due to V². Further experiments are quoted, using subdivided and other types of gap.

The third part of the paper investigates the influence of N. Using continuous current it was easy to vary N by increasing the charging current. The effect of this is seen in the following table:—

Charging current, amps.	1.7×10^{-8}	2.9×10^{-8}	5.1×10^{-8}	10.0×10^{-8}	14.8×10^{-8}
Received current, divns.	1.6	24	42	96	144

The paper concludes with experiments on the spark frequency, using spark-gaps from which air was excluded (Lepel gap), gaps in hydrogen, and vacuum spark-gaps.
H. H. H.

1723. *The Propagation of Electromagnetic Waves in Wireless Telegraphy.* G. R. Dean. (Electrician, 78, pp. 896-898, Sept. 11, 1914.)—The first Part of this contribution was mentioned in Abstract No. 1110 (1914). The second Part deals with the Hertzian element in an imperfect dielectric; Part III. with the simple Hertz element.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1724. *Electrical Conductivity of Alloys of Copper and Tin.* N. A. Puschin and A. V. Baskov. (Russian Physico-Chem. Soc., Journ. 45, pp. 746-752, 1918.)—The curves showing the variation of (1) the specific resistance, and (2) its temperature-coefficient with the composition of copper-tin alloys consist each of six branches, corresponding with the following ranges of composition (atom. % of Sn): 0-7, 7-20, 20-25, 25-40, 40-50, 50-100. The resistance curve shows a minimum and the temperature coefficient curve a maximum at 25 atom. % of Sn, the magnitude of the coefficient being similar to the values obtained for pure metals; these results indicate the
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existence of a definite chemical compound, Cu_3Sn , and are in agreement with those of thermal analysis, etc. The low value of the temperature-coefficient corresponding with the composition Cu_3Sn indicates the formation, not of a definite compound, but of a solid solution.

Whilst the addition of tin to copper causes a very rapid increase in the resistance, copper produces but little change in the resistance of tin.

T. H. P.

1725. *Electrical Conductivity of Liquid Sulphur Dioxide: New Photoelectric Phenomenon.* J. Carvallo. (Journ. de Physique, 4. Ser. 5. pp. 887-899, May, 1914).—The conductivity of liquid sulphur dioxide, determined by means of a Wheatstone bridge and an alternating current, varies considerably with its method of preparation. (A) When it is purified by repeated fractional distillation in a vacuum in diffused daylight its conductivity at 16° is about 10^{-1} "practical" or ohm-cm. units. (B) If such a sample is exposed to daylight for several days the value increases to as much as 10^{-8} . (C) If, however, the fractional distillations are replaced by fractional rectifications in a vacuum and with complete protection from daylight, the value is about 5×10^{-9} , which is maintained as long as the sample is kept in the dark. The increased conductivity resulting from the action of light is explained by the slight decomposition of the sulphur dioxide by ultra-violet light ($\lambda < 890$), according to the equation, $8\text{SO}_2 = \text{S} + 2\text{SO}_3$. The conductivity of sample (A) is diminished very considerably (from 57.8 to 0.18×10^{-10}) by the passage of a continuous current, and this effect is far more marked (from 8190 to 1.6×10^{-10}) with sample (B) which has been exposed to the light; with sample (C), however, such effect is scarcely perceptible. The changes in (A) and (B) are attributed to an electrolytic purification of the sulphur dioxide.

The photoelectric sensitiveness of very dilute solutions of sulphur and sulphur trioxide in liquid SO_2 has been investigated, the results indicating that the action of light is of a twofold character: (1) A positive effect, which causes gradual increase of the conductivity and due to the chemical change expressed by the equation given above. (2) A negative effect, which must be regarded as a property of solutions of the products of the photochemical reaction in excess of the initial liquid; it is, indeed, coexistent with these products, and is determined by the action of light on the electrical, and not on the chemical, properties of the liquid. This negative effect is not felt when alternating currents are employed.

T. H. P.

1726. *Electrical Properties of Silver Sulphide.* F. A. J. FitzGerald. (Amer. Electrochem. Soc., Trans. 25. pp. 898-418, 1914).—The electrical properties of silver sulphide, which has a negative temperature coefficient of resistance, have been studied in connection with its use in an automatic fire alarm [see Abstract No. 44B (1914)]. The sulphide is found to be a solid electrolyte well suited for investigations on compounds of this class. The temperature-resistance curve shows a critical point at a certain temperature, but this is not the same on the heating and cooling curves. The curve is considerably affected by the presence of small proportions of impurities, such as copper, and even very slight chemical reduction has a marked effect on the resistance. Lack of homogeneity in the sulphide made from silver-copper alloy has an important influence on the resistance and probably also on the thermoelectric and rectifying effects. Silver-silver sulphide and copper-silver sulphide form thermoelectric couples. Electrolysis may occur in a $\text{Cu} | \text{Ag}_2\text{S} | \text{Cu}_2\text{S} | \text{Cu}$ cell in a 25- \sim alternating-current circuit, with the result that the cell is eventually short-circuited, but

if the electrodes are of silver the cell is not short-circuited. In the former case, this is probably due to a persistent rectifying effect, any such effect gradually disappearing when silver electrodes are used. With the latter cell, there is a critical temperature at which the rectifying effect disappears and a different one at which it reappears on cooling; these temperatures may be correlated with the critical points of the temperature-resistance curves.

T. H. P.

1727. *Electrical Resistance and Optical Properties of Thin Layers of Platinum.* B. Pogány. (Phys. Zeitschr. 15. pp. 688-690, July 15, 1914.)—Planck has recently given results for the optical properties of thin layers of copper [see Abstract No. 1676 (1914)]. In order to explain his results he supposes that with layers of very small thickness the free path of the free electrons decreases, which means, in Drude's theory, that the frictional resistance becomes greater. Thomson [see Abstract No. 1522 (1901)] has shown from his theory of metallic conduction that if λ is the mean path in massive metal, d the thickness of the layer, then the diminished path λ' is given by $4\lambda' = d[8 + 2 \log(\lambda/d)]$, the formula holding good for layers whose thickness is at least of the order of magnitude of the mean path. It follows from this that the specific resistance increases with decreasing thickness of layer, as Patterson has already shown. Measurements have now been made with thin layers of Pt and of Ag. The present paper deals with the results obtained with Pt. The layers were obtained by cathodic deposition, and then the resistances were measured by a Wheatstone bridge method. The thickness of the deposit was estimated from weighings made with a micro-balance which was sensitive to about 4×10^{-8} gm. The results thus obtained are based on the assumption that the density of the deposit is independent of the thickness. On plotting the results it is seen that the specific resistance for relatively thick layers is constant until a thickness of $7 \mu\mu$ is reached. When the thickness decreases beyond this value, the specific resistance increases rapidly. Following Planck, an investigation was then made to see whether the observed variation of electrical conductivity was accompanied by variations of the optical properties. The indices of refraction and absorption for different layers were obtained, using a Fuess spectrometer. The curves show a general qualitative agreement with the theoretical conclusions of Planck. With the exception of the curve for $(n^2 - k^2)$, the curves all exhibit similar effects to those obtained by Planck for thin copper layers. For the curves showing the values of k and $2nk$ for different thicknesses, characteristic maxima were found; the curve for n showed a steady fall with increased thickness. The maximum of $2nk$ is perhaps slightly more marked than for copper, and the variation of n with the thickness is less than for copper. The curve for $(n^2 - k^2)$ shows a sharp minimum at about $7 \mu\mu$. Above this value n and k vary only slowly, and their values for a thickness of $28 \mu\mu$ approximate to those for massive Pt.

A. W.

1728. *Resistivity of Silver.* E. F. Northrup. (Frank. Inst., Journ. 178. pp. 85-87, July, 1914.)—The author extends his investigations of the resistivity of metals to the case of pure silver throughout a range of temperature from 20° to 1840° C. The silver is first dealt with as a soft drawn wire, its resistivity being determined between 20° and 60° C.; it is then used in a container which can be heated above the melting-point of silver. Results are plotted in a set of curves. Within the limits of accuracy of measurement, the increase of resistivity from 20° to 60° C. is found to be linear. For the

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wider range from 20° to 960°C. , corresponding to the solid state, the resistivity curve shows slight convexity towards the temperature axis. At the moment of fusion the resistivity suddenly increases from about 8.5 to 16.6 microhms.-cm. Making allowances for shrinkage in solidifying, the author considers that the ratio of resistivities after and before fusion may be taken as 1.98 . Within similar limits of accuracy it is found that the resistivity of silver in the molten state increases linearly from its melting-point to 1840°C. , which was the highest temperature measured. R. A.

1729. Thermoelectric Forces produced by Deformation, and their Application to the Measurement of Elastic Hysteresis. K. Baedeker and W. Vehrigs. (Ann. d. Physik, 44. No. 5. pp. 788-800, June 19, 1914.)—In a circuit consisting of one single metal thermoelectric forces can be produced by having the circuit unequally heated and subjecting it to deformations which vary from point to point, e.g. if a wire is bent so that one part can be kept hot and another cold, whilst a straight portion of it is extended, thermoelectric forces are produced. Considering a rectangular parallelepiped with its edge parallel to the chief axes of pressure, the thermoelectric forces along these directions may be expressed in terms of the pressures as follows, assuming the deformations to be within the elastic limit: $e_x = c_x X_x + c_y Y_y + c_z Z_z$; $e_y = c_x X_x + c_y Y_y + c_z Z_z$; $e_z = c_x X_x + c_y Y_y + c_z Z_z$: the two constants c_x and c_y being involved. For a simple extension we get $e_x = c_x X_x$, and $e_y = e_z = 0$. Other simple expressions are given for the cases of (1) homogeneous pressure, (2) torsion, (3) a tube under internal and external pressure. Various metals were investigated in the form of tubes within the elastic limit, and the linear relations were found to hold fairly well. The tube was bent in such a way that an upper bend in the tube was kept at 100°C. and the lower portion at 0°C. , the vertical portion joining the two bends being subjected to extension, compression, torsion, etc., modifications being introduced for the various special cases.

This principle was applied to the measurement of elastic hysteresis, curves being obtained similar to the familiar curves of magnetisation, here of course, the abscissæ being of the dimensions of pressure, and the ordinates microvolts per degree. In one case—a steel tube—a complete hysteresis curve was obtained between equal positive and negative pressures. This involves many difficulties, and so most other cases investigated were for either positive or negative pressure. Just as in the magnetic case, a reversible effect is obtained for small variations of the pressure. When no hysteresis occurs, i.e. for small variations, it was proved that the effects due to two distinct influences are additive. When hysteresis is present, one influence modifies the hysteresis due to another influence very considerably, just as in the case of magnetisation with the application of pressure or torsion. The following examples of this are given: Hysteresis of extension during the application of (a) an internal pressure, (b) a constant torsion, (c) magnetisation, and (d) hysteresis of torsion during the application of a constant torsion. With soft metals it was found that the thermoelectric forces are proportional to the tension and are reversible until flowing occurs, when a permanent effect sets in. The suggestion is made that the explanation of these effects will most probably be found along lines similar to the molecular theory of magnetism. J. R.

1730. An Application of Electrolytically-produced Luminosity, forming a Step towards a Form of Telectroscopy. L. H. Walter. (Roy. Soc., Proc. Ser. A. 90. VOL. XVII.—A.—1914. 2T

pp. 487-440, July 80, 1914.)—The author has investigated the conditions under which it should be possible to make practical use of the luminosity of anodes of alloyed aluminium forming part of a "valve" cell arrangement. The alloy known as "duralumin" is found to give the best results, and with sodium tungstate solution as electrolyte, corrosion is practically eliminated when this alloy is used as the anode. The difficulties with immersed anodes led the author to employ anodes which are completely dry, except as regards the front surface, which is kept wetted by means of a layer of electrolyte caused to flow down it in a continuous stream, the flow being distributed by using a transparent crêpe screen which clings to the anode surface. In this way, the anode being dry at the back, electrical connection can be directly established there, without the great care as to insulation otherwise needed. This arrangement permits of the construction of an apparatus having a multiple anode, comprising a vast number of equal units in quite a small compass, each such unit being able to be rendered luminous in any order or sequence desired and at a speed of some hundreds of times per sec. In the author's experimental apparatus there are over 5000 such separate units in a space the size of a cabinet photograph, or at the rate of over 24,000 per sq. ft.—a number which it would hardly be possible to obtain by other means. Such an apparatus is capable of being employed as a receiver in photo-telegraphy for the reproduction of pictures, etc., especially where these are received as electrical impulses. It constitutes a step towards one form of telectroscopy, the luminous reproduction at some receiver, of an object visible at some distant electrically-operated transmitter.

AUTHOR.

1731. *An Interference Oscillograph*. A. Guyau. (Journ. de Physique, 4. Ser. 5. pp. 195-206, March, 1914.)—The microscope is frequently employed nowadays not only in the Science laboratory, but also industrially, for observing and photographically recording small movements. The author has designed an apparatus [see also Abstract No. 1056 (1918)] which records, by interference, oscillations of the order of $1/100000$ mm. A small mirror is mounted on the vibrating surface. In front of the mirror a second mirror is placed so that a thin layer ($\frac{1}{10}$ mm.) of air intervenes. A beam of light is concentrated on the air space by means of two lenses, and through a system of prisms interference fringes are projected on a horizontal screen. In front of the screen is placed a recording drum which is given a helical motion, and the movement to be observed is recorded in oblique co-ordinates. Knowing the distance apart of two consecutive fringes, V , and the orthogonal displacement v , the displacement u of the moving surface is connected by the relation $u = \lambda v / 2V$. The design and construction of the necessary apparatus is very fully gone into by the author, but it is not possible to reproduce the illustrations, and the paper should therefore be referred to.

H. H. H.

1732. *A Null Method of Testing Vibration Galvanometers*. S. Butterworth. (Phys. Soc., Proc. 26. pp. 264-272; Discussion, pp. 272-278, June, 1914.)—The methods usually employed in the determination of the constants of a vibration galvanometer involve the measurement of a deflection under three different conditions. Two of these deflections can only be obtained very approximately. By extending the theory of the vibration galvanometer it is shown how the constants may be determined by methods which involve only the measurement of one deflection. The remaining measurements are carried out on an alternating-current bridge, and the results obtained are practically independent of the wave-form of the source. The principle of the method

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depends on the fact that a vibration galvanometer behaves as a parallel combination of a conductance, a capacity and an inductance, in series with a resistance. It is shown how to balance such a combination, and the method is illustrated experimentally. The constants of various galvanometers are quoted in order to show the applicability of the method. Other uses of the bridge are suggested. AUTHOR.

1733. Alternating-current Method of comparing an Inductance with a Capacity. J. P. Dalton. (Phil. Mag. 28. pp. 37-44, July, 1914.)—The author discusses the methods of Maxwell, Rimington, and Pirani for comparing self-inductance with capacity. He shows that in the two latter methods the conditions of balance, when alternating current is used, are only true for one particular frequency. He describes a method in which, as in Anderson's, an exact balance is obtained at all frequencies, and the method is therefore called a continuous balance one. The condenser is inserted between one corner of the bridge and a point on one of the opposite arms. F. E. S.

1734. Einthoven String Galvanometer. A. C. Crehore. (Phil. Mag. 28. pp. 207-224, Aug., 1914.)—Gives the mathematical theory of this instrument, and obtains formulæ. It is hoped in a future paper to give experimental results for comparison and for determination of the constants involved. E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1735. Initial Permeability of Iron and Magnetite as a Function of the Temperature. P. Weiss and K. Renger. (Archiv f. Elektrotechnik, 2. pp. 406-418, 1914.)—Starting from the experimental result of Rayleigh and others that $\mu = a_p + b_p H$, where a_p and b_p are constants, rings of electrolytic iron and artificial magnetite were investigated by a ballistic method over a range of temperature -200° to 800° C. For iron it was found that a_p , the initial permeability, was a simple function of the saturation intensity at the same temperature. A change of state was observed to take place in iron at 220° C., and besides the already known temperature 180° , at which ageing takes place most rapidly, a second temperature was found at 880° which is separated from the first by a range of temperature, beginning at 150° , within which ageing does not take place. By subjecting the specimen to six or seven alternations of temperature between 800° and 700° C., a very high initial permeability of 755 was obtained at ordinary temperature. This value fell rapidly with time to about 100. With regard to the creeping or slow growth in intensity in a given field, it was found that magnetisation took the longest time at a temperature of -11° C. In the case of magnetite, the value of a_p has a maximum at -188° C. besides that at 568° C. After the first thermal treatment, the initial magnetisation was independent of the previous history and unaffected by the course of the magnetic fields. [See also Abstract No. 526 (1911).] G. E. A.

1736. Properties of Magnetically-shielded Iron. E. Wilson. (Roy. Soc., Proc. Ser. A. 90. pp. 848-849, July 1, 1914.)—In continuation [see Abstract No. 1880 (1914)], experiments were made with stalloy rings at high temperatures. By allowing the material to cool through the critical temperature while shielded from the earth's magnetism and subjected to a field of about

8 gauss, the permeability was greatly increased, and values of μ higher than 10,000 were obtained. The higher max. permeability in low fields was accompanied by lower permeability at higher values of the induction. The hysteresis loss is lower than in normal stallo for a given magnetic induction. [See also Abstract No. 1229 (1911).] G. E. A.

1737. *Magnetisation in Rapidly-oscillating Fields.* H. Rohmann. (Ann. d. Physik, 44. 6. pp. 817-848, July 8, 1914.)—A magnetised bar is more or less demagnetised when placed in an oscillating magnetic field of which the amplitude continuously decreases. On the other hand, an unmagnetised bar may be magnetised by means of the discharge of a battery of condensers. The magnetism produced depends partly on the amplitude of the alternating magnetic field and partly on the manner in which the field diminishes to zero. Further, the magnetising action of a damped vibration changes qualitatively even when its course is changed by a definite but relatively small amount. Experiments are described showing the effect of the superposition of two damped sine oscillations which give rise to more complicated vibrations. G. E. A.

1738. *Magnetic Induction in Heusler Alloys at High Frequencies.* H. Fassbender. (Archiv f. Elektrotechnik, 2. pp. 475-489, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The alloy investigated had a composition of 14.25 Mn, 10.15 Al, and about 75 Cu. After subjecting the material to thermal treatment and to an ageing process, in order to obtain it in as magnetically soft a condition as possible, the induction was measured in maximum fields of 21.6, 82.4, and 48.2 gauss, for frequencies of 47,200, 65,200, 97,500, and 119,000, the B-curves being obtained by means of a Braun tube. For theoretical confirmation of the experimental values, the differential equation for the field within the specimen, as modified by the skin-effect, was deduced from Maxwell's theory. The solution gives the distribution of the field, the total flux and the mean induction. G. E. A.

1739. *Molecular Field in Diamagnetic Substances.* A. E. Oxley. (Cambridge Phil. Soc., Proc. 17. No. 5. pp. 450-451, May 5, 1914.)—Following up the work on specific heats by Nernst and Lindemann, by Debye and by Planck and Einstein, the author treats mathematically the case of a diamagnetic crystalline structure and finds an increase of specific heat corresponding to rotational vibrations. This increase presents a maximum value in the neighbourhood of the fusion-point. Experiment shows evidence of such a maximum for sodium and mercury. [See Abstract No. 446 (1918).] E. H. B.

1740. *Qualitative Method for the Study of the Magnetic Susceptibility of Solutions.* A. Quartaroli. (N. Cimento, 7. pp. 159-164, March, 1914.)—By means of truncated conical poles a field is obtained in which a zone of great intensity is separated sharply from one of feeble intensity. The solution to be examined is introduced into a glass tube of 8-10 mm. diam., and above it is placed, carefully and without mixing, coloured water. The tube is then arranged between the poles so that the surface of separation of the two liquids corresponds with the lower point where the poles begin to diverge. When the magnet is excited the water bulges out into the magnetic solution below without sensibly mixing with it, and, if the field is sufficiently intense, a globule of the water becomes detached and remains suspended in the
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magnetic liquid. The phenomenon is visible with weak fields and dilute solutions, which yield scarcely perceptible indications by Plücker's or the U-tube method. Naturally, the results become more marked as the specific gravities of the two liquids approach equality. T. H. P.

1741. *Magneto-chemical Phenomena*. A. Ščukarev [Schükarew]. (Phys. Zeitschr. 15. pp. 670-678, July 1, 1914.)—If two exactly similar Pt plates, immersed in a mixture of 0.05-N ferric chloride and 0.1-N potassium iodide solutions, are electrically connected outside the liquid through a galvanometer, the latter indicates the flow of a current, which diminishes as the reaction proceeds. Many other reacting mixtures exhibit a similar phenomenon, the current being independent of the stirring of the liquid and passing from the larger to the smaller plate, if plates of unequal size are used. When the plates are similar and the solution is placed between the poles of a powerful electromagnet, the magnetic field exerts no influence on the chemical polarisation current when the plates are parallel to the lines of force and symmetrical towards the central line. But if the plates are somewhat unsymmetrically arranged, the field causes a new polarisation current, which is added to the original one and passes from the plate in the more intense to that in the less intense part of the field. No magneto-polarisation is observed when the Pt plates are perpendicular to the lines of force. Marked magneto-chemical effects of this character occur in the case of reactions taking place at the electrodes during electrolysis. T. H. P.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1742. *Applications of the Coolidge Röntgen-ray Tube*. W. P. Davey. (Gen. Elect. Rev. 17. pp. 792-798, Aug., 1914.)—The main advantages in the use of the Coolidge tube are (1) the independence of the quantity and the penetrating ability of the rays produced, (2) the ease and rapidity with which the quantity and penetration of the rays may be regulated, and (3) the fact that when the tube is once adjusted to the requirements of the operator it needs no further attention. To bring the tube to any desired adjustment, the operator pulls a handle which regulates the current through the tube, thus determining definitely the quantity of Röntgen rays produced. He then adjusts the voltage across the tube until the penetration is of the desired degree. The radiographs reproduced show what a wide range of work can be done with a single Coolidge tube, and they suggest that this tube is destined to become a precision-instrument of value to the botanist, biologist, and mineralogist, as well as to the physicist and the physician. A. E. G.

1743. *Measurements of Quality and Quantity of Röntgen Rays*. W. E. Schall. (Röntgen Soc., Journ. 10. pp. 45-53; Discussion, pp. 53-54, July, 1914.)—The Christen penetrometer is first considered. Christen suggested that the penetrating power of Röntgen rays should be expressed in terms of the thickness of tissue necessary to absorb exactly one-half of the radiation which strikes the skin. The explanation of the method of doing this is given. In the Bauer qualimeter the penetrating power of the tube is indicated on the scale; but the readings may not be taken as absolute readings of penetrating power because they depend too much on the frequency of the interrupter, and the type of Röntgen-ray apparatus used. When, however, the operator has calibrated it to his own installation and knows which reading on its scale corresponds to, say, 7 or 9, etc., Wehnelt, it is very useful to indicate the

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penetrating power. Tables comparing the values of the Benoist, Wehnelt, Christen, and Bauer radiometers are given. It should be borne in mind that the penetrating power of the tube ought to be measured with the current which it is proposed to use or else allowance must be made for increasing hardness due to a larger current than the one used for measuring.

There are at present in use two methods for dosage : the indirect and the so-called direct. The relative advantages and disadvantages of these are considered with special detailed reference to the chemical quantimeter of Kienböck and the Ionto quantimeter. A table is given comparing the values of the Sabouraud-Noiré, Holzknecht, Kienböck, Ionto, Hampson, and Bordier quantimeters. In the *discussion*, G. W. C. Kaye stated that it was a question in any tube what proportion of the kathode rays generated Röntgen rays : the subject needs much experimental work. Any satisfactory instrument based on an ionisation method must give, at any rate, a constant proportion of the whole of the energy in the Röntgen ray, or some attempt must be made at completely absorbing the Röntgen ray, otherwise one would get the roughest notion which would be of little value. There is the same difficulty with the pastille.

A. E. G.

1744. *Spark Inductors and Röntgen Rays*. C. Déguisne. (Phys. Zeitschr. 15. pp. 680-688, June 15, 1914.)—The apparatus used is briefly described and curves are given to illustrate the results obtained such as : Curves showing the relationship between primary and secondary currents at different times when a tube of medium hardness is employed, and Current and voltage curves for soft tubes.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1745. *Two New Modifications of Phosphorus.* P. W. Bridgman. (Amer. Chem. Soc., Journ. 86. pp. 1844-1868, July, 1914.)—Under the influence of high pressure, ordinary white phosphorus is transformed into a new modification. The transition temperature is a linear function of the pressure and varies from about -80° at the atmospheric pressure to $+64.4^{\circ}$ at 12,000 kg. per sq. cm. This modification was obtained in microscopic crystals, probably of the hexagonal system. A black modification has also been obtained by subjecting the ordinary white form to a temperature of 200° and a pressure of 12,000 kg. per sq. cm. This variety, the formation of which is irreversible, has the high density, 2.691, at the ordinary temperature and possesses moderately high electrical and thermal conductivity. Its specific heat between 80° and 100° is 0.170, which is decidedly lower than the corresponding value for red phosphorus, the latter being apparently less stable than the black form. The relations between the different modifications of phosphorus are discussed. [See also Abstract No. 1680 (1914).] T. H. P.

1746. *Adsorption of Acetylene by Palladium-black.* C. Paal and C. Hohenegger. (Ber. Deut. Chem. Gesell. 46. pp. 128-182, 1918.)—In the authors' previous investigation on the same subject the palladium-black was suspended in aqueous solutions of various substances. They have now investigated the adsorption of acetylene, using either suspensions of palladium-black in pure water, or else dry palladium-black. The experiments in which 60 % alcohol was used in place of pure water were also repeated. In all cases the adsorption of the acetylene takes place slowly, and the results given do not point to any fixed ratio between the weight of Pd and the amount of gas adsorbed. It is probable that the acetylene is not completely adsorbed as such, but undergoes partial polymerisation. When the dry palladium-black is not completely free from oxygen, formation of feeble sparks occur immediately it is brought into contact with the acetylene. T. S. P.

1747. *Separation of Corpuscles in Chemical Reactions.* S. M. Tanatar and E. Burkser. (Russian Physico-Chem. Soc., Journ. 45. pp. 1-6, 1918.)—Immersion of a charged conductor connected with an electroscope into the gas evolved during the catalytic decomposition of hydrogen peroxide by platinum-black shows the gas to be strongly ionised. A thin Al plate placed under the base of the glass vessel retards the loss of charge. Similar experiments were also made on the oxidation of sodium sulphite or arsenic trioxide by hydrogen peroxide solution. The results do not allow of any definite statement concerning the cause of the ionisation observed. T. H. P.

1748. *Behaviour of Hydrogen towards Palladium.* A. Gutbier, H. Gebhardt, and B[erta] Ottenstein. (Ber. Deut. Chem. Gesell. 46. pp. 1458-1457, 1918.)—The authors have investigated the absorption of hydrogen by Pd at temperatures varying between -50° and $+105^{\circ}$. The Pd was used in the form of sponge, which was obtained by heating ammonium palladichloride in an oxygen-free stream of CO_2 , the temperature used being as low
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as was consistent with the expulsion of all the ammonium chloride. The results obtained are in agreement with those of Paal and Amberger—namely, that with decrease in the temperature there is a considerable increase in the absorption; they contradict the results of Hemptinne (1899), and of Baerwald (*Comptes Rendus*, 145. p. 202, 1907). The absorption is a minimum at 20°.

The palladium hydride obtained was pyrophoric.

T. S. P.

1749. *Two Lecture Experiments on the Diamond*. W. Prandtl. (*Ber. Deut. Chem. Gesell.* 46. pp. 216–217, 1918.)—Moissan's method of making diamonds may be modified as follows: In a cylindrical can of sheet metal, 10 cm. in diam. by 12 cm. high, is placed another cylinder, open at both ends, of less diam., and the space between the two filled with dry, powdered fluorspar. The inner cylinder is then filled with a mixture of 200 gm. of iron thermit and 10–15 gm. of powdered coke, after which it is withdrawn, so that the thermit mixture is surrounded at the sides by the fluorspar, but is in direct contact with the bottom of the sheet metal can. The can is fixed on an iron ring placed above a vessel containing mercury covered with a layer of 15–20 cm. of water, and the thermit mixture fired. The liquid iron dissolves the carbon, melts through the bottom of the can, and is quenched in the water and mercury. The iron is then treated in the usual way to obtain the microscopic crystals of diamond, which are accompanied by some doubly refracting, hexagonal plates, probably of carborundum.

The combustion of a diamond in oxygen can be conveniently shown by heating it in a quartz test-tube, fitted with a cork through which pass inlet and exit tubes for the oxygen and products of combustion respectively. The combustion of the diamond is started by heating that part of the quartz tube on which the diamond rests with a blowpipe flame.

T. S. P.

1750. *Preparation of Cerium and its Alloys*. M. Moldenhauer. (*Chem. Zeit.* 88. p. 147, 1914.)—Cerium oxide is not reduced to cerium by the Goldschmidt method, using either Al, Mg, or Ca. Cerium fluoride is, however, readily reduced by excess of Ca, giving an alloy containing 12 % Ca and about 88 % Ce; it is necessary to cover the crucible with a layer of calcium fluoride during the reaction, in order to prevent oxidation. If the cerium fluoride is mixed with iron oxide, reduction with Ca gives an alloy of Ce and Fe containing 40 % Ce. If the Ca is replaced by Al, an Al (10.2 %)—Ce (25.8 %)—Fe (62.5 %) alloy is produced.

All the above alloys show the properties of the ordinary iron-cerium alloy.

T. S. P.

1751. *Atomic Weight of Lead of Radio-active Origin*. T. W. Richards and M. E. Lumbert. (*Amer. Chem. Soc., Journ.* 86. pp. 1829–1844, July, 1914. *Comptes Rendus*, 159. pp. 248–250, July 20, 1914.)—In order to test the theory that the nature of the end-product of the process of disintegration of a radio-active mineral will vary according to the proportion of the parent substances in the mineral, parallel determinations have been made of the equivalent weights of various samples of lead chloride from different sources. It is found that all the radio-active specimens possess lower atomic weights than ordinary lead, the deficiency in one case amounting to as much as 0.75 of a unit. No simple linear relationship between the exact amount of radio-activity and the atomic weight is evident. Comparison of the ultra-violet spectrum of a typical radio-active sample with that of ordinary lead revealed only negligible differences. These results appear to lead to the conclusion that radio-active lead contains an admixture of a substance differing from

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ordinary lead and very difficult of elimination by chemical means. This substance cannot be identified in the ultra-violet spectrum of the material, because either it has the same spectrum as lead, or it has no spectrum in that part of the field, or its spectrum is masked by that of the lead. These results are contrary to the experience obtained with other elements, notably Cu, Ag, Fe, Na, and Cl, each of which seems to give a constant atomic weight, no matter what the geographical source. The theoretical aspects of the facts presented are not discussed, but attention is drawn to their qualitative agreement with the hypothesis of Fajans and of Soddy [see Abstract No. 1075 (1918)].

T. H. P.

1752. The Preparation of Sodium. B. Neumann and S. Giersten. (*Zeitsch. f. angew. Chemie*, 27. pp. 65-70, 1914.)—The authors have constructed a large, experimental apparatus, on the principle of the Castner apparatus, for the preparation of sodium by the electrolysis of fused sodium hydroxide, using, however, a special arrangement by which the water formed at the anode is evaporated largely by the heat of the fusion and is prevented from coming into contact with the sodium at the kathode. The best conditions of current and temperature were investigated, and are discussed in detail, as also the various phenomena which occur during electrolysis. The most important factor for successful electrolysis is the temperature, which, in the katholyte, must be maintained very close to that of the melting-point of the sodium hydroxide. Pure sodium hydroxide does not give such good results as the commercial substance, owing to its high melting-point. Current yields of 58 % were obtained, whereas the average yield in the manufacturing process is 80 to 40 %.

The details of the authors' experiments and considerations can only be appreciated by reference to the original paper.

T. S. P.

1753. Heats of Cooling of Aluminium, Iron, Antimony, and Nickel. P. N. Laschtschenko. (*Russian Physico-Chem. Soc., Journ.* 46. pp. 811-838, 1914.)—The amounts of heat developed by these metals during cooling were measured in the manner previously described [Abstract No. 1580 (1918)]. The aluminium used contained 0.81 % Si and 0.63 % Fe, but was free from copper and lead. The curve connecting the amount of heat developed by 1 gm. of Al in cooling from any given temperature to 23-24° with this temperature, is continuous to 580°, and is somewhat convex towards the temperature axis. Between 580° and 590° a marked change in the direction of the curve occurs, and at 670-650° a sudden increase in the amount of heat, owing to fusion of the metal. The heat of fusion is found to be 71 cal. per gm. Even when the metal is melted and heated at 700-720° it exerts no action on the quartz tube, and only at 750° does the formation of Si occur.

In the experiments with iron, the metal used was free from pearlite, and contained only minimal inclusions of slag. The heat-of-cooling curve shows two marked changes in direction, at 780° ($\alpha\text{-Fe} \rightleftharpoons \beta\text{-Fe}$) and 895° ($\beta\text{-Fe} \rightleftharpoons \gamma\text{-Fe}$) respectively, and beyond 900°, when the iron is in the γ -form, the specific heat increases rapidly with rise of temperature. Measurement of the heat of cooling of electrolytic iron confirms the temperature 780° for the change of α - into β -iron. The conversion of the β - into the α -modification is accompanied by the development of 5 cal. per gm. or 0.28 cal. per gm.-atom, and that of γ - into β -iron by about 6.1 cal. per gm. or 0.88 cal. per gm.-atom.

The nickel employed was of 99.89 % purity. The heat-of-cooling curve shows a break at 855-865°, in complete agreement with previous observa-

tions, and indicates, further, the existence of a third modification of nickel stable above 700°. This indication is confirmed by the change of the metal at high temperatures into a brittle form with a coarsely crystalline structure. The first transformation, at 868°, is accompanied by the development of about 8.11 cal. per gm.-atom.

Antimony was investigated at temperatures ranging from 200 to 680°, and within these limits the heat of cooling curve is quite continuous. This metal melts at 680°, and the latent heat is 4.85 cal. per gm.-atom. T. H. P.

1754. Electrical Conductivity of Alloys of Copper and Zinc. N. A. Puschin and V. N. Rjashski. (Russian Physico-Chem. Soc., Journ. 44, pp. 1905-1918, 1912.)—Investigation of the electrical resistance and of its temperature-coefficient for alloys of copper and zinc gives results in general agreement with Shepherd's conclusions based on the melting-point diagram and on the microstructure [Abstract No. 2774 (1904)]. The system forms (1) the solid solutions: α , 0-86 atom. %; γ , 59-67 atom. %; ϵ , 80-85.7 atom. %; and η , 91-100 atom. % of zinc; (2) the mixed crystals: $\alpha + \beta$, 86-50; $\beta + \gamma$, 50-59; $\gamma + \epsilon$, 67-80; and $\epsilon + \eta$, 85.7-91 atom. % of zinc. The existence of the solid solution, β , within narrow limits is regarded as a sign of the existence of the definite compound ZnCu, which is slightly dissociated at the ordinary temperature. The results also indicate the probable existence of the two compounds Zn₃Cu and Zn₅Cu [compare also Norsa, Abstract No. 1575 (1912)]. T. H. P.

1755. Iron-Titanium Alloys. J. Lamort. (Ferrum, 11, pp. 225-234, May 8, 1914.)—The equilibrium diagram of these alloys has been studied by the methods of thermal analysis. Alloys containing up to 24 % Ti were prepared by melting ferro-titanium with mild steel in a Kryptol furnace. The liquidus consists of two branches meeting in a eutectic point at 1800° C. and a composition of about 18 % Ti. Iron retains about 6 % Ti in solid solution. Microscopic analysis confirms the results of the thermal study, and also indicates the existence of a compound Fe₃Ti. Study of the magnetic properties showed that the temperature of the magnetic change is lowered by the addition of Ti. The curve showing the relationship between temperature of magnetic change and the Ti-content is practically a straight line running from 0 % Ti and about 787° C. to 21 % Ti and 690° C. The iron-titanium alloys are possessed of higher remanence values than iron itself. The Brinell hardness rises rapidly with the Ti-content, a 21.5 % Ti alloy having a hardness of about 500. Chemical and microscopical tests were also made on ferro-titaniums both with and without carbon. The presence of both nitride and cyano-nitride can readily be recognised under the microscope. The effect of additions of titanium to iron and steel most likely depends on whether the Ti exists in the alloy in the metallic state or in the form of nitride. This probably accounts for the variations in the results obtained by different workers in this field. F. C. A. H. L.

1756. Iron-Zinc Alloys. F. Taboury. (Comptes Rendus, 159, pp. 241-243, July 20, 1914.)—In galvanising vats, in which the zinc remains for some months at a temperature just above its melting-point, crystals are deposited which are identical in composition with the mixed crystals containing 7.8 % of iron observed by Vegesack [see Abstract No. 789 (1907); see also Vigoroux, Duceilliez, and Bourbon, Abstract No. 1465 (1912)]. T. H. P.

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1757. Contribution to the Theory of Hardening. A. McCance. (Iron and Steel Inst., Journ. 89. pp. 192-244; Discussion and Correspondence, pp. 245-265, 1914. Engineering, 97. pp. 828-827, June 12, and pp. 854-856, June 19, 1914.)—Experiments have been made to determine the variations in the hardness, electrical resistance, magnetic properties, density and sonority of steels of different carbon-content with the quenching temperature. Little variation occurs in the hardness until above A_{c1} , when the greater proportion of the increase takes place within an interval of 20–80° C. In hypoeutectoid steels the max. hardness is obtained when the quenching temperature is above A_{c3} , but in hypereutectoid steels it is only necessary to heat slightly above the cementite change-point; higher temperatures resulting in the formation of austenite which softens the material. In all steels with above 0.7 % C the max. hardness obtainable was constant, indicating that there is a max. amount of hardening which the iron itself can stand. Steels containing over 0.7 % C, when quenched from 840° C. all show practically the same hardness, while there is a great difference in the amounts of non-magnetic material present, the latter increasing with the presence of austenite. The cooling curve of a round bar during quenching closely follows the theoretical curve calculated on the assumption that the surface of the bar is at 100° C. after immersion, and that the cooling takes place according to the mathematical theory of conduction for this condition. When the temperature of the quenching water is below 20° the hardness values are uniformly high, but above 60° C. the values are low, while between these limits there is an unstable area in which the values show considerable variation, possibly because of the steam not being able to escape so readily. There are only two allotropic modifications of iron: α and γ ; β iron being merely α iron which has lost its ferromagnetism owing to thermal causes. The thermal disturbances at A_2 are due to sudden changes in the specific heat which has recently been shown to accompany change in magnetic intensity. The author holds the definition of allotropy to be at fault, and considers that only a change in crystalline symmetry is to be defined as an allotropic change. During quenching two changes go on in the steel—a slow change in which the carbon is deposited from solution and a rapid conversion of the γ into α iron. The amount of carbon retained in solution therefore is proportional to the rate of cooling through A_{r1} , but no practical rate of cooling is sufficiently rapid even appreciably to retard the allotropic change. Experiments showed that although the rate of quenching did not affect the hardness after all the carbon had been retained in solution, it did have an appreciable effect on the rate of tempering, owing to the higher amount of austenite retained in solution. The retention of carbon in solution retains part of the iron in the γ condition, but the major portion is still in the α condition. Since at the temperature of quenching the crystalline grains had the symmetry of γ iron, the γ iron will form an internal network in the original grains. The rest of the iron will be transformed to crystal units of α symmetry, but lack of time, internal friction, and the γ network prevent their arrangement into homogeneously orientated α crystals. The α iron will therefore be in a condition of interstrain, resulting in great hardness. Cracks in hardened steel may be caused either by stresses set up by irregular heating or by stresses set up by irregular cooling. Both causes produce definite modes of cracking, the first cause producing radial cracks in round bars and cracks in the centre of the sides of square bars. The second cause produces circles concentric with the surface in round bars, and rectangular hyperbolæ whose origins are the four corners of the square, in square bars.

F. C. A. H. L.

1758. *The Hardening of Metals with Special Reference to Iron and its Alloys.* C. A. Edwards and H. C. H. Carpenter. (Iron and Steel Inst., Journ. 89. pp. 188-177 ; Discussion and Correspondence, pp. 178-191, 1914. Engineering, 97. pp. 885-891, June 26, 1914.)—The authors discuss the formation of twin crystals, the amorphous theory, and the theories of hardening carbon steels, at some length. During annealing, the softening of the mass is brought about by the gradual removal of the hard amorphous material existing as an envelope round the crystals. The growth of the crystals is probably brought about owing to the unstable nature of the amorphous material which tends to crystallise, and forms the medium whereby the material of one grain is transposed to the next. Photomicrographs are reproduced which indicate that carbon steels show a tendency to form twin crystals when quenched from above A_{r8} . The type of twinning is somewhat different from that produced by annealing after deformation. In the latter case more than two twins are seldom formed in one grain, while in the former case the twins are exceedingly numerous, and frequently appear to intersect each other. At the surfaces of slip on which twinning occurs amorphous layers are formed, and the authors consider that it is to the presence of this amorphous material that quenched steels owe their ultimate hardness. In the case of austenitic steels the presence of the special elements gives rise to the formation of compounds of high molecular weight, which exert a greater osmotic pressure and lower the temperature at which the carbon is rejected from the solution. At the same time the velocity of the change is decreased to such an extent that quenching is not necessary to preserve the mass in the austenitic condition. No twinning occurs in this case, because the pressure necessary to inhibit the carbide change is already inherent in the mass as osmotic pressure, and no internal crystalline disturbance can take place. Evidence is also given as to the constitutional identity of austenite and martensite, the apparent difference under the microscope being due to twinning. F. C. A. H. L.

1759. *Introduction to the Study of the General Properties of Tool Steels.* Denis. (Rev. de Métallurgie, 11. pp. 569-570, June, 1914.)—The multiplicity of tool steels all put to the same use and the differences in the results obtained on the same brands of steel in different works appear to indicate variations in the thermal treatment owing to the neglect of carrying out systematic tests previous to the use of the steel. A certain number of brands of tool steels seem to be preferred by a large number of works but on different grounds. To determine if this preference is based on real grounds the author has made, in the workshops of the French Army and Navy, a systematic study of the properties of tool steels, and has divided his report into three parts: (1) General considerations of the methods of testing tool steels and of the thermal treatments which may be applied to them. (2) Various tests made on the principal brands of tool steel used in industry, with the object of determining the best thermal treatment corresponding to any of their various uses. (8) Conclusions of the tests. Characteristics of the steels studied, from the point of view of their constant use. F. C. A. H. L.

1760. *Tempering and Annealing of Quenched Copper-Tin and Copper-Zinc Alloys.* A. Portevin. (Comptes Rendus, 158. pp. 1174-1177, April 27, 1914.)—It has already been shown that on tempering a 10 % Al alloy of copper, the pro-eutectoid constituent separates in such a way that a Widmanstätten structure is produced and that the beginning of tempering is marked by an increase of hardness [Abstract No. 607 (1912)]. It appeared to be of interest

to determine if this behaviour were common to all alloys containing a eutectoid. The increase of hardness on tempering copper-tin alloys has already been observed by Grenet [Abstract No. 408 (1911)].

An alloy containing 80.11 % Cu, after quenching from 700° C. consists of the α and β constituents. On tempering at temperatures gradually increasing from 800° to 600° C. fine needles of the δ constituent appear in the region previously occupied by β . The orientation of these needles (Widmanstätten structure) persists even after completely annealing the alloy. Experiments have also been carried out on a pure brass containing 57.91 % Cu, quenched from 825° and tempered at temperatures gradually increasing from 400° to 800° C. The quenched alloy had a hardness of 96, while after tempering at 400° C. the value had increased to 106. Here again, tempering produces a Widmanstätten structure at low temperatures, but as the temperature rises α separates out in thin plates between the original β grains. At 800° C. the Widmanstätten structure is destroyed owing to the coalescence. Similar results were obtained with an alloy containing 25 % Zn and 5 % Al. F. C. A. H. L.

1761. *A New Reagent for Etching Mild Steel.* W. Rosenhain and J. L. Haughton. (Iron and Steel Inst., Journ. 89. pp. 515-524; Correspondence, pp. 525-526, 1914. Engineering, 97. pp. 788-785, June 5, 1914.)—A brief account of this reagent has already been given in Abstract No. 1004 (1914). Satisfactory results are only obtained when the composition of the reagent conforms with considerable exactitude to the following formula:—Ferric chloride 80 gm., conc. Hydrochloric acid 100 c.cm., Cupric chloride 1 gm., Stannous chloride 0.5 gm., Water 1 litre. In pure carbon-steels the resulting pattern is the reverse of that produced by picric acid, but the most important property of the new reagent lies in the fact that it reveals in an unmistakable manner the distribution of phosphorus in mild steels, yielding results which are comparable with those obtained by heat-tinting. The cause of the pattern is due to the deposition of very thin films of copper. In unhardened steels ferrite is coloured black, while in hardened steels martensite is developed in a remarkably clear manner. In commercial steels patterns identical with those obtained by heat-tinting are obtained. The new reagent is extremely sensitive to the presence of phosphorus, the ferrite containing the least amount of phosphorus in solution being darkened first. It is therefore much more sensitive than picric acid in revealing the presence of phosphorus. It appears that the width and distribution of the phosphorus banding depends upon the size and arrangement of the crystals in the original ingot. There is always considerable darkening round the enclosures of slag and sulphides in steel, which appears to indicate that there is a concentration of dissolved impurities in the immediate vicinity of such enclosures. F. C. A. H. L.

1762. *Application of the Theory of Allotropy to Electromotive Equilibria.* II. A. Smits and A. H. W. Aten. (Konink. Akad. Wetensch. Amsterdam, Proc. 28. pp. 87-54, July 8, 1914.)—It has been previously shown [see Abstract No. 1024 (1914)], by application of the theory of allotropy to the electromotive equilibrium between metal and electrolyte, that a metal exhibiting the phenomenon of allotropy and therefore composed of molecules of different kinds will, when immersed in an electrolyte, emit different ions, possibly of equal size but varying in structure and perhaps in electrical charge. The disturbance of the internal equilibrium between a metal and its solution by electrolytic dissolution of the metal, being attended by a diminution of the more active molecules, will bring about a diminution of the chemical activity,

whereas cathodic disturbance exerts the opposite influence. For very small current densities the internal equilibrium should generally be able to maintain itself, the p.d. with respect to an auxiliary electrode being zero when the metal is either anode or cathode. With increasing current density the metal will become superficially further and further removed from the state of internal equilibrium and the p.d. with respect to the auxiliary electrode will greatly increase. But as this change proceeds and the surface of the metal becomes increasingly metastable, the velocity of the reaction tending to destroy the metastability would increase owing to the change of concentration in the homogeneous phase. Investigations have been made with a number of different metals immersed in solutions of the corresponding salts, the anodic and cathodic polarisation p.d.'s being measured. The internal equilibrium is established rapidly with Ag, Cu, and Pb, and very slowly with Ni, Cd occupying an intermediate position. With Bi, Fe, and Al, catalytic influences are apparently exercised.

T. H. P.

1763. Allotropy of Cadmium. II. and III. **E. Cohen and W. D. Helderman.** (Konink. Akad. Wetensch. Amsterdam, Proc. 23. pp. 54-58, and pp. 122-131, July 8, 1914.)—Further dilatometric investigations [see Abstract No. 772 (1914)], described in Part II, show that the supposed transition temperature, 64.9° , varies with the thermal treatment to which the cadmium has been previously subjected, and it is concluded that there are more than two allotropic forms of cadmium concerned.

Part III contains a description of investigations of Hulett's low-voltage standard cell, cadmium | cadmium sulphate solution | cadmium-amalgam containing 12.5 % of Cd, the Cd electrolyte being deposited electrolytically [see Abstract No. 1982 (1905)]. The e.m.f. of such a cell is 0.0505 volt at 25° when the Cd has just been deposited, but it gradually falls to 0.047 volt. The suggestion that this change in e.m.f. is due to the gradual transformation of unstable γ -cadmium into the stable α -modification is supported by the observation that the diminution in the e.m.f. is considerably increased by lowering the temperature from 25° to 0° . Further, the Cd deposited electrolytically is withdrawn from the 12.5 % (or stronger) amalgam, which was originally a two-phase system, so that it is possible for this layer to become a monophasic system, the e.m.f. then increasing if the electrolysis is continued. After the formation of the cell its e.m.f. will then be too high, but Cd will ultimately diffuse to the upper layer, which then resumes its two-phase character, the e.m.f. thus decreasing and finally attaining constancy. It is found, indeed, that replacement of the Cd amalgam, after deposition of the Cd, by 12.5 % amalgam gives a cell with an immediate e.m.f. of 0.0508 volt.

Various phenomena which were described by Hulett and were formerly obscure are explainable in the light of the above results.

T. H. P.

1764. Aluminium-Nickel. The Nickel-plating of Aluminium. **E. Tassily.** (Rev. de Métallurgie, 11. pp. 670-673, June, 1914.)—None of the large number of the methods which have been patented for nickel-plating aluminium appear to give satisfaction in practice. Generally, the nickel is deposited on an intermediate coat of copper, zinc, or iron, but even then the adherence leaves much to be desired. A method recently patented by Carnac permits the direct deposition of an adherent coating of nickel which can be polished, will stand hammering and heating, and, in fact, the result behaves so much like

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an alloy that the author has been led to call it Aluminium-Nickel. The method consists in passing the metal through a bath of boiling potash, brushing with milk of lime, soaking for some minutes in a 0.2 % potassium cyanide solution, and finally treating in a bath of 500 gm. HCl, 500 gm. water, and 1 gm. of iron until the Al assumes a mottled metallic appearance. After each operation the metal is well washed in water. Nickeling is carried out in the ordinary way in a bath containing 50 gm. nickel chloride, 20 gm. boric acid, and 1000 c.cm. of water, using a current at 2.5 volts and a density of 1 amp./dm.². The success of the process appears to depend on the thorough cleaning and the fact that a thin layer of iron is deposited on the Al from the ferruginous bath. That there is a layer of iron on the metal is proved by the fact that on testing by means of the magnetic balance the susceptibility of metal which has been through this bath is 14 times as great as that of the metal which has simply been boiled in potash. Microscopic examination of the surface reveals the presence of small cells in which the Ni is deposited during electrolysis, the process being assisted by the formation of numerous small couples. The resulting product resists the action of moist air, hot and cold acids and alkalis, hot concentrated salt solutions, alcohol, and does not permit the sweating of petrol. Compared with pure Al the tensile strength is increased, the coefficient of expansion decreased, while the density is only slightly increased. It can be applied in railway construction, shipping, the manufacture of instruments, cooking utensils, and so on. F. C. A. H. L.

1765. Polarisation Single Potentials. C. N. Hitchcock. (Amer. Electrochem. Soc., Trans. 25. pp. 416-440, 1914.)—The author has investigated the potential at anode and kathode in the case of the electrolysis of sulphuric acid solutions (generally a normal solution) at voltages below the normal decomposition point. The electrodes were of Pt and of varying sizes. It was found that decomposition of water takes place at any voltage, provided the electrodes are of the proper size. The oxygen normally present in laboratory reagents is sufficient to produce marked depolarisation at the kathode. The single potential of each electrode so depends on that of the other that any change in one, due to disturbing influences, is counteracted by such a change in the other that, below the decomposition point, the sum of the separate electrode polarisations equals the total polarisation, which, at the same time, is very nearly equal to the impressed e.m.f. Any desired current may be passed through an aqueous solution of sulphuric or hydrochloric acid without causing evolution of gas, provided the electrodes are made large enough. The evolution of gas at the electrodes depends on the total current density minus that part of the current density neutralised by the action of depolarising agents. T. S. P.

1766. Electrolytic Deposition of Brass on a Rotating Kathode. C. W. Bennett and A. W. Davison. (Amer. Electrochem. Soc., Trans. 25. pp. 847-866; Discussion, pp. 866-887, 1914. Journ. Phys. Chem. 18. pp. 488-509, June, 1914.)—The electrolytic deposition of brass from mixed solutions of the cyanides of zinc and copper has hitherto yielded unsatisfactory results, and, consequently, the authors have made a series of experiments with other solutions of salts of these metals, using rotating kathodes. Preliminary measurements were made of the voltages required to deposit copper and zinc from a number of different salt solutions, the voltages being measured against an oxygen electrode. Those solutions giving similar curves
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were then studied with a view to obtaining a good deposit of brass, but in no case, save that of the mixed cyanides, could such a deposit be obtained. Investigation of the reasons for this showed that the deposition of brass from cyanide solutions depends probably on two factors : (1) the tendency of the potentials of copper and zinc to become the same in the cyanide solution, and (2) the increase in the potential of the more noble metal, by impoverishment. The latter factor is practically eliminated by using the rapidly rotating kathode. A *satisfactory* brass has not been deposited from the cyanide solution on the rotating kathode ; the alloy obtained is brittle, the brittleness being probably due to occluded impurities which arise from the cyanide and cannot therefore be removed. The metal ratio of copper to zinc in solutions for the deposition of a brass varies, not only with variations of free cyanide, but also with the rate of rotation of the kathode. [See Abstract No. 1294 (1912).] T. S. P.

1767. *Electro-deposition of Cadmium.* F. C. Mathers and H. M. Marble. (Amer. Electrochem. Soc., Trans. 25. pp. 297-318, 1914.)—A review of the work which has been published on the electro-deposition of cadmium from (a) solutions of cadmium salts of inorganic acids (sulphuric, nitric, halide, hydrofluosilicic, hydrocyanic and phosphoric acids), (b) ammoniacal solutions, (c) solutions of cadmium salts of organic acids (oxalic, formic, acetic, lactic, succinic, and tartaric acids). There is also a section on commercial plating and refining. T. S. P.

1768. *Effect of Addition Agents in the Electro-deposition of Iron.* O. P. Watts and M. H. Li. (Amer. Electrochem. Soc., Trans. 25. pp. 529-538, 1914.)—The electrolyte chosen as a basis for the addition of various substances consisted of 150 gm. of crystallised ferrous sulphate and 75 gm. of ferrous chloride ($\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$) per litre, and had a specific gravity of 1.125 at 20° C. Ammonium sulphate (120 gm. per litre) was found to give good results as an addition agent, the sulphates of sodium, magnesium, and aluminium not being satisfactory. Using the solution containing ammonium sulphate, the effect of a large number (48) of organic addition agents was tried ; of these, only ammonium oxalate and hexamethylene tetramine improved the remarkably smooth and satisfactory deposit given by the original electrolyte. Solutions of ferrous ammonium fluosilicate or fluoborate are not satisfactory electrolytes. T. S. P.

1769. *Electrolytic Deposition of Zinc.* J. W. Richards. (Amer. Electrochem. Soc., Trans. 25. pp. 281-288 ; Discussion, pp. 288-290, 1914.)—An account is given of results obtained : I. In the refining of impure zinc when (a) precious metals are absent, (b) the anodes contain precious metals ; II. In the direct extraction of zinc from its compounds using (a) soluble anodes containing zinc compounds, (b) soluble anodes containing no zinc, (c) insoluble anodes, but using the electrochemical reaction at the anode, (d) insoluble anodes and not utilising the electrochemical reaction at the anode. T. S. P.

SCIENCE ABSTRACTS.

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ERRATA.

Abstract No. 1652, p. 571, line 5 : *for* $L(k\sqrt{d^2|t})$, *read* $L(k|d^2|t)$.

Abstract No. 1657, line 12 : *for* x , *read* \times (= multiplied by).

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1914.

GENERAL PHYSICS.

1770. *Pendulum of Constant Length and Variable Rate.* **L. Labocchetta.** (N. Cimento, 7. Ser. 6. pp. 40–58, Jan., 1914.)—A disc or ring of mass M is supported by an axis passing normally to its plane through its centre of gravity. A body of mass m is attached to its rim. The period of oscillation is then $2\pi [R(1 + \mu)/g]^{1/2}$, where $\mu = M/m$. If another small body m' is substituted for m , and $\mu' = M/m'$, the ratio of the periods is given by $P/P' = (1 + \mu)/(1 + \mu')$, and hence also the ratio of the masses m and m' . The pendulum thus serves as a balance. E. E. F.

1771. *Large Measuring Machines constructed by Société Gènevoise.* (Engineering, 98. pp. 828–828, Sept. 11, 1914.)—One of these is adapted to measure a gauge of even 8 m. long. One new feature in the machine is a rolling foot, allowing that change in temperature shall produce no strain along the length of the bed. The most accurate of the machines described measures to 1 micron. It has a peculiarity already described [see Abstract No. 797 (1914)], viz. the reference scale, instead of being fixed, is placed at the horizontal level of the micrometer screw and moves with it. The advantage here is that a cosine error (instead of as usual a sine error) is introduced. P. E. S.

1772. *New Reference Mark in Stereo-comparator.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 84. pp. 221–233, July, 1914.)—This mark has the form of a balloon with a point at its lower end. It swings freely in the air and in use is brought over or near the object sighted. It is more under control than the ordinary device. P. E. S.

1773. *Reduction of Paris Wireless Rhythmic Time Signals.* **R. A. Sampson.** (Roy. Astronom. Soc., M.N. 74. pp. 545–548, April, 1914.)—A suggestion is made for the use of all the sets of rhythmic time signals for the reduction of time observations, instead of the first and last only as proposed in the
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Paris Circular. Examples are given of the extra check thus provided, and details given of actual time determinations showing the extreme value of these signals for delicate investigations.

C. P. B.

1774. *Distribution of Time Signals.* P. Sève. (Comptes Rendus, 159. pp. 284-286, July 20, 1914.)—Describes an improvement on the alternate-current transmitter of angular displacements devised by Abraham [Abstract No. 586B (1911)]. The new device gives a powerful action on the receiving instrument, which does not react on the transmitter. As there are no breaks of circuit, there is little danger of failure, and the receiver, after any interruption, takes up the position of the transmitter automatically. The receiver is analogous to the alternate-current galvanometer devised by Franklin and Freudenberg [Abstract No. 492 (1907)]. It consists of two coils with horizontal axis and normal to each other, surrounding two soft-iron needles inclined at 45° . The two coils connect with the two secondaries of the transmitter, and the horizontal projections of the needles follow the resultant of the two alternating fields due to the coils. The apparatus is specially adapted to the controlling of clocks, and to transmission of time.

E. E. F.

1775. *The Litre.* C. Lallemand. (Comptes Rendus, 158. pp. 1297-1801, May 11, 1914.)—Originally the word "litre" was simply a synonym for "cubic decimetre"; but in 1880 the International Commission of Weights and Measures defined the litre as the volume of a kilogramme of water. This has introduced a dualism which is troublesome. The kilogramme is too great to correspond to the mass of 1 cub. dm. of water at 4° C. and 76 cm. pressure, by $(27 \pm 1$ or $2)$ mgm.; it corresponds to the mass of 1 cub. dm. of pure water at 4° C. and (117 ± 2) cm. Hg column. The author advocates a return to the original definition for almost all practical purposes; then those who wanted a litre representing the volume of 1 kilogramme of pure water at 4° C. and 76 cm. pressure could specify this as a "metrologic litre" and could say that the density of water at 4° C. and 76 cm. was not unity but 0.999 978.

A. D.

1776. *A.E.F. Physical Units and Symbols.* (Deutsch. Phys. Gesell., Verh. 16. 4. pp. 170-179, Feb. 28, 1914.)—Weight a force, not a mass; product of mass into g . Density; mass-density or specific mass, mass per unit of volume, $=m/V$; weight density or specific weight, units of weight per unit of volume, $=mg/V$; density proper or density-ratio (sp. gr.), referred to standard substance, $=(m/V)/(m_0/V_0)$ or $(mg/V)/(m_0g/V_0)$; mass-volume (specific volume), volume per unit of mass, $=V/m$; weight-volume (specific weight-volume), volume per unit weight, $=V/mg$. Symbols: Energy, W ; period, T ; frequency of cycle, ω ; frequency in alternating current, f ; specific resistance, ρ ; conductivity, G ; electrostatic induction, D ; dielectric constant, ϵ ; counter-inductivity, M ; magnetic flux, Φ . Unit of heat energy, the international kilojoule or kilowatt-hour, $=0.238865$ of a 15° C. kilogramme-calorie: 1 k.-cal. $=4.19$ kilojoules.

A. D.

1777. *Stresses in a Plate near a Plugged Hole.* K. Suyehiro. (Engineering, 98. pp. 281-282, Aug. 14, 1914. Paper read before the Soc. of Mech. Engin., Japan, April, 1914.)—An extension of a previous paper on stresses in plates having discontinuities. By a mathematical investigation which cannot be usefully abstracted it is found that concentration of stress due to the

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presence of a hole may be reduced by filling the hole with a plug. The theoretical results represent well the general features of the stress distribution experimentally determined by Coker [see Abstracts Nos. 906 and 1778 (1918)]. J. W. T. W.

1778. *Poisson's Ratio for Vulcanised Rubber*. L. Bouchet. (Comptes Rendus, 159. pp. 470-472, Aug. 31, 1914.)—Describes a continuation of previous experiments [see Abstract No. 1877 (1914)] on the elasticity of rubber subjected to very small deformations. A disc of rubber was placed between two metal discs forming an electric condenser. The whole was immersed in a chamber filled with water and provided with a capillary so that any change in the volume of the rubber could be at once detected. On charging the condenser to a potential reaching 58.5 c.g.s. electrostatic units there was no measurable change of volume. This confirmed the result of the previous paper [*l.c.*] that for very small deformations the value of Poisson's ratio for rubber is 0.5. J. W. T. W.

1779. *Flow in Metals under Large Constant Stresses*. E. N. da C. Andrade, Roy. Soc., Proc. Ser. A. 90. pp. 829-842, July 1, 1914.)—The author has continued the work described in Abstract No. 1669 (1910), with the object of determining if the empirical laws determined for lead were applicable to other metals, and also to investigate the effect of temperature on the flow. The metals investigated were lead, tin, iron, copper, mercury, a lead-tin alloy, brass, and German silver. It was found that, without exception, all the pure metals gave extension-time curves which closely correspond to the equation $l = l_0(1 + \beta^{1/n})e^{kt}$, deviations of the calculated from the observed values never exceeding 2 per cent. In the equation l_0 represents the immediate length on loading, β is a measure of that part of the flow whose rate decreases as the time increases, and k measures the final or viscous flow. The values of these constants depend upon the temperature and at a given temperature with increasing stress, β tends towards a constant value while k increases at a rate which itself increases to a constant value. The main result of this part of the work shows that metals of widely different nature obey the same general laws of flow over a range of temperature. Small quantities of impurities do not affect the general type of extension-time curves. Duplex alloys show an anomalous behaviour. At a certain stage of the flow produced at certain temperatures the wire softens instead of showing the hardening which is common to the pure metals. At other temperatures, however, alloys were found to behave normally. By subjecting to a high preliminary stress either in tension or torsion wires can be put into a state in which they will flow viscously from the start of subsequently applied smaller stresses. Photomicrographs of strips of soft iron extended at different temperatures showed that slip-bands were formed with equal distinctness and frequency, regardless of whether the extension took several minutes or was produced immediately. On the basis of the co-existence of the crystalline and amorphous phases an explanation of these various phenomena has been worked out. When a wire is loaded, there is an immediate stretching owing to a slip between, and inside, favourably disposed crystals. An immediate redistribution of stress then takes place, with the result that other less favourably placed crystals begin to slip and give rise to the β flow. There is a limit to the ultimate number of lamellæ which can be produced, corresponding to the production of elementary crystals. This is represented by the limit VOL. XVII.—A.—1914.

to which β tends with increasing stress. If the amorphous material is capable of flow it gives rise to the viscous or k flow. At low temperatures the amorphous phase is hard, but as the temperature rises it softens at a relatively greater rate than the crystalline material. There is obviously no limit to the viscous flow.

F. C. A. H. L.

1780. *Flowing Pressure and Hardness of Plastic Bodies.* N. S. Kurnakow and S. T. Żemczużny. (Rev. de la Soc. russe de Métall. 1. pp. 256-810, 1918. Rev. de Métallurgie, 11. pp. 881-888, June, 1914. Abstract.)—Plastic materials occupy an intermediate position between the solid and liquid states. Under slow deformation they resemble liquids of high viscosity, and under rapid deformation they resemble fragile elastic solids. There is in such materials an exact parallel between the hardness and the flowing pressure at constant velocity—a fact which has been established by determining the Brinell hardness and the pressure required to cause a certain definite rate of flow for 100 different materials. The pressure-time curves may be divided into four types which indicate that there is no sharp line of demarcation between plastic and fragile materials. Solids which appear to be fragile under rapid rates of flow can be made to act like plastic materials either by decreasing the rate of flow or by increasing the temperature. The study of the viscosity of several binary systems has also been undertaken and has led to the following conclusions:—(1) The formation of solid solutions is marked by an increase of the general hardness and the flowing pressure. (2) The variations in the hardness of a continuous series of solid solutions may be represented by a continuous curve showing a maximum. (3) The hardness of a simple mechanical mixture is a linear function of the composition. (4) In a solid solution the coefficient of hardness at a given temperature is greater than that of either of the components. (5) The hardness and electrical conductivity diagrams are just the reverse of each other (antibates): the five types of diagrams for hardness and electrical conductivity are illustrated. The degree of purity of metals may be estimated from a knowledge of the hardness or the flowing pressure, this method being more sensitive than that based upon a determination of the electrical conductivity. This is confirmed by the fact that while commercial lead has a flowing pressure of 8.5 to 12.4 kg./mm.², Kahlbaum's pure product has a flowing pressure of only 6.6 kg./mm.². The variations in the hardness in relation to the corresponding changes in the modulus of elasticity have been studied in the case of the copper-nickel alloys which form a continuous series of solid solutions. While the hardness shows a maximum at about 45 % Ni the modulus is a rectilinear function of the composition. The results of the authors' work indicate that the application of viscosimetry to the study of solids will show differences between the various states of matter which cannot be made evident by other methods.

F. C. A. H. L.

1781. *Critical Loads for Long Struts of Varying Section.* L. Bairstow and E. W. Stedman. (Engineering, 98. pp. 408-404, Oct. 2, 1914. Communication from the National Physical Laboratory.)—Describes a new method for the practical determination of the critical loads of struts such as those used in aeroplane construction where the ends are generally tapered according to no definite law. Consider a strut symmetrical about its centre and of length $2l$. Then if I_x is the least moment of inertia of the section of the strut at a distance x from the end at which the assumed

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critical load W is applied, while E is the modulus of elasticity and y the deflection at the point x , $-EI_x(d^2y/dx^2) = Wy$. By a method of trial and error and successive approximation, curves are built up for $-d^2y/dx^2$, dy/dx and y . The ordinate of the dy/dx curve becomes zero when x is greater or less than l according as the assumed value of W is respectively below or above the true critical load. After two attempts a very close approximation to the value of W is reached. The stresses in the strut when failure occurs may be found from the usual formula $M/I = f/b$, where b is the distance of the outside fibres from the neutral axis and f is the stress. Then $f = bM/I = -Eb(d^2y/dx^2)$, i.e. f is proportional to $b(d^2y/dx^2)$, and thus can be found from the curve for d^2y/dx^2 , as soon as b has been determined from the form of the section. By drawing a curve of distribution of stress, and employing, as before, a method of trial and error a form of strut with uniform resistance to bending may be arrived at. J. W. T. W.

1782. Rupture Stresses in Beams and Crane Hooks. A. R. Fulton. (Roy. Soc. Edinburgh, Trans. 50. 1. pp. 211-228, 1918-1914.)—In previous experiments [see Abstract No. 225B (1918)] on the failure of timber under stress it was found that when the fracture point was reached, either (1) the tension and compression areas of the stress diagram both assumed the limiting form of rectangles whose ordinates were respectively equal to the ultimate breaking stresses of the material in direct tension or compression; or (2) the cohesion between adjacent fibres measured from the neutral axis outwards was insufficient to withstand the shear induced by the resisting moment of the beam. The formulæ for the ultimate extreme fibre stresses in tension and compression (t and c respectively) deduced in the previous paper [*loc. cit.*] have now been verified by experiments on cast-iron beams. The theory, previously applied only to rectangular beams, has also been extended to include beams of any section, provided the ultimate distribution of stress may be assumed rectangular, and this assumption has been justified by experiments on 9 different forms of wrought-iron beams. The theory has been further applied to cases of non-axial loading, such as crane-hooks, the further conclusions, justified by experiment, being in this case (8) that, provided shear does not take place, the neutral axis moves always to the position which reduces the summation of the tensile and compressive stress areas, across a section, to the equilibrant of the external forces (in the case of a beam this reduces to zero; in that of a hook, at the principal section, to the suspended weight); and (4) that the total resisting moment of these stresses must be equal to the external bending moment as measured to the neutral axis at rupture point, but that these balancing moments do not differ materially from those measured to an axis obtained by dividing the sectional area into tensile and compressive stress areas which are in inverse proportion to the magnitude of their respective ultimate direct stresses. J. W. T. W.

1783. Determination of Fatigue Limits under Alternating Stress Conditions. C. E. Stromeyer. (Roy. Soc., Proc. Ser. A. 90. pp. 411-425, July 20, 1914.)—Reference is made to Wöhler's work on endurance of metals and to bending fatigue tests by Margetson. A special torsion fatigue-testing machine is described, in which the test-piece is surrounded by an india-rubber sleeve with inlet and outlet pipes cemented into it through which water is passed, these latter pipes containing sensitive mercury thermometers. By this means it is possible to determine the heat generated in the test-piece, precautions

being taken by measurements at other points to determine the flow of heat from or to outside connections. Diagrams and tables of results are given for various classes of steel and some non-ferrous alloys. C. O. B.

1784. *Mean Density of Fractured Rocks.* G. F. Becker. (Washington Acad. Sci., Journ. 4. pp. 429-481, Sept., 1914.)—The author opines that since rupture may cause a change in density, fissures in rocks represent voids as the elasticity of volume for crystalline solids is held to be perfect. Now orogenic movements are accompanied by extensive and minute fissuring as well as by folding and distortion, and in many instances what at first sight resembles plastic folding or contortion turns out on close inspection to have resulted from the crushing of a bed or layer under confinement. An example of this is cited by the author in the Coast Ranges of California. The case of a brittle bed bent under confinement is discussed and applied to the Coast Ranges, where if the voids amount throughout to 5 % the elevation produced by these alone would average about 20,000 ft. Now 5 % is of the order of magnitude of the interstitial space in closely piled spheres of radius similar to that of the average fragment, so that the diminution of density due to crushing is of the order of magnitude requisite to account for the variations of topography in a sense compatible with isostasy. The author does not assert that the formation of voids explains orogeny, but deems it worthy of consideration in tectonic theory. H. H. Ho.

1785. *Change of Density of Sulphur with Rupture.* A. F. Melcher. (Washington Acad. Sci., Journ. 4. pp. 481-484, Sept., 1914.)—These determinations were undertaken in connection with Becker's work on the mean density of fractured rocks [see preceding Abstract]. Six trial specimens were prepared, brass tubes of two different lengths and three different diameters being filled with sulphur. After the density of the samples had been determined, they were bent as nearly into the form of a complete circle as could conveniently be done, and the new density measured. The preparation and filling of the tubes with sulphur—operations involving considerable difficulty—is described in detail. The data obtained, although not of the utmost precision, are close enough to show that there is a decrease in density due to the rupture of the order of magnitude of 0.0678, which is the square of 0.2595, or of the interstitial space in closely piled spheres of equal radius. This approximation is apparently due to the rounding-off of the edges and corners of the fragments formed at the inception of bending. The present experiments indicate that 6.78 % is the limiting value for sulphur subjected to shear under ordinary hydrostatic pressure. H. H. Ho.

1786. *Flow of Gases and Vapours from Nozzles.* H. Parenty. (Comptes Rendus, 158. pp. 1973-1977, June 29, 1914.)—Reverts to past work and history, and points out the inexactitude of the equation of St. Venant and Wantzel when the conditions are anything but steady and adiabatic. The fact that the coefficient of the jet may exceed unity is explained by the author as due to non-uniform conditions over a cross-section. The author supports his analysis by the experimental results of Rateau. H. S. R.

1787. *Vortex Motion in a Perfect Fluid.* A. Gray. (Phil. Mag. 28. pp. 1-12 and 18-18, July, 1914.)—The first of these Notes on Hydrodynamics, both of which are mathematical, is an improved presentation with new matter of results given in a former paper by the author [Roy. Soc. Edinburgh, VOL. XVII.—A.—1914.

Trans. 1906]. The second note is a direct and elementary demonstration of the validity of the value given, without proof, by Kelvin for the translational velocity of a vortex ring in an unlimited fluid, in a note appended to Tait's translation of v. Helmholtz's celebrated paper [Phil. Mag. 38. 4th Ser., 1867].
G. W. DE T.

1788. *Flow of Liquids*. P. Alibrandi. (N. Cimento, 6. Ser. 6. pp. 228-248, Oct., 1918.)—Shows that the "adherence" of a liquid to a solid wall is strictly an impossibility unless there is a vertical component of the attractive force, which in general is negligible. But the displacement of the liquid along the wall may be so slow as to render the hypothesis of adherence a workable one.
E. E. F.

1789. *Action between Bodies moving in a Liquid*. E. Almansi. (N. Cimento, 7. Ser. 6. pp. 144-158, March, 1914.)—Investigates in what cases a force between periodically moving bodies, or bodies periodically changing their shape or size, may be expected when the bodies are immersed in a liquid, without regard to the strength of the force.
E. E. F.

1790. *Hydrodynamical Analogy of Gravitation*. E. Almansi. (Accad. Lincei, Atti, 23. pp. 287-291, March 1, 1914.)—Gives a more general mathematical treatment than that of C. A. Bjerknes and V. Bjerknes, and arrives at the conclusion that the attractive constant is inversely proportional to the square of the period of the alteration in form or position of a body immersed in a homogeneous liquid.
E. E. F.

1791. *Kinematical Interpretation of the Relativity Principle*. C. Munari. (Accad. Lincei, Atti, 23. pp. 781-787, May 17, 1914.)—Bases the interpretation upon the sole kinematical condition that "a uniform rectilinear motion of velocity c , affected by the Lorentz transformation, is transformed into another uniform rectilinear motion of velocity c ."
E. E. F.

1792. *Relativity Theory*. J. Ishiwara. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 4. pp. 149-161, 1913.)—A descriptive and critical survey of the theory of relativity.
E. H. B.

1793. *Surface Tensions of Liquids in Contact with Different Gases*. A. Ferguson. (Phil. Mag. 28. pp. 408-412, Sept., 1914.)—Apparently the only investigations on the effect of the nature of the superincumbent gas on the surface tension of a liquid are those of Forch and of Bönicke (Winkelmann, *Handbuch der Physik*, 2nd Edition, vol. i. p. 1178) made by the capillary-rise method. The latter not being an ideal method for the determination of capillary constants, the author has made use of Jaeger's method, in which the surface tension of the liquid is arrived at by observations of the max. pressure required to release a bubble of gas from the end of a vertical capillary tube plunged below the surface of the liquid; not only is this method more sensitive than the capillary tube method, but it is independent of a knowledge of the contact-angle between the liquid and the tube. The author has recently developed a formula expressing the surface tension in terms of certain easily observed quantities [see Abstract 1656 (1914)]. Carbon dioxide and air were the gases chosen, and measurements were made with benzene, turpentine, water, methyl and ethyl alcohols, chloroform, and ether. Two factors contribute to the total effect caused by the gas, namely, that actually due to
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the nature of the gas in contact with the liquid and that due to the solubility of the gas in the liquid; these two factors seem to be inseparable, but evidence exists which indicates that the former is the more important of the two.

The experimental results given below are in C.G.S. units, the mean value of the surface tension at a liquid-air surface being called T and that at a liquid- CO_2 surface at the same temperature, $T + \delta T$, so that $\delta T/T$ represents the effect of replacement of the air by CO_2 :—

Substance.	Temp.	T (air).	$T + \delta T(\text{CO}_2)$.	$\delta T/T$.
Benzene	17°	29.87	28.88	— 0.0184
Chloroform	17	27.79	27.22	— 0.0206
Water	15	78.88	78.04	— 0.0114
Methyl alcohol	17	28.88	22.97	— 0.0154
Ethyl alcohol	18	28.12	22.84	— 0.0121
Ether	15	17.88	17.65	— 0.0129
Turpentine	18	27.98	27.85	— 0.0046

The value usually given for the surface tension between turpentine and air is 26.7 dynes per cm. at 18°. Assuming that this value is really $T \cos \theta$, θ being the angle of contact of turpentine with glass, it follows that $\cos \theta = 26.7/27.98 = 0.9541$, so that $\theta = 17.5^\circ$, which agrees closely with the value obtained by Magie (Phil. Mag. p. 162, 1888), from measurements of the total depth of a large bubble of air imprisoned in the liquid under a convex lens.

T. H. P.

1794. *Isostasy in India.* W. Bowie. (Washington Acad. Sci., Journ. 4. pp. 245–249, May 19, 1914. Abstract of paper read before the Philosoph. Soc., Washington, April, 1914.)—Recent investigations by the United States Coast and Geodetic Survey indicate that for the total area of the country isostasy is practically perfect, while the gravity reductions show that areas of smaller extent are largely compensated. These points are only brought into prominence by the new Hayford method of reduction, and as this method is now being used in India and Italy a comparison of the results was made. An analysis is made of the results published for 14 gravity stations in India, all approximately in the same longitude, and extending from lat. $+28^\circ 16'$ to $+28^\circ 19'$. The values at the different stations vary in size and sign, and seem to indicate local rather than regional departures from the perfect isostatic state; but the data, though small in amount, show that isostasy may be nearly as perfect for large areas in India as in the United States.

C. P. B.

1795. *New Paths of Physical Knowledge.* M. Planck. (Phil. Mag. 28. pp. 60–71, July, 1914.)—The fundamental changes in the main structure of physical theories are essentially constructive—not destructive—leading to modification and amplification of existing theory by the old way—conflict between experimental fact and portions of hitherto accepted theory. Now, as before, the great physical principles still hold the field—*e.g.* The Conservation of Energy, The Conservation of Momentum, Least Action, The chief laws of Thermodynamics. But assumptions hitherto accepted almost without question are proving untenable, or at any rate doubtful, *e.g.* The Invariability of Chemical Atoms, The Mutual Independence of Space and Time, and

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The Continuity of all Dynamical Effects. The fact of heat evolution by radium compounds placed the first in conflict with the Conservation of Energy, and the principle holds the field. If relativity be assumed to be experimentally established, the Mutual Independence of Space and Time comes into conflict with the so-called principle of the Constancy of the Velocity of Light established, by the electrodynamics of Maxwell and Lorentz. The latter has so far held the field, and it is not at all probable that any abandonment of that position will occur. The assumption of the Continuity of all Dynamical Effects had long been accepted as a basis for all physical theories, but is now found in direct conflict with the experimental facts which have given rise to the Quantum Hypothesis. The disintegration of the energy of motion of water waves by continuous diminution of amplitude does not proceed indefinitely, but finds a certain limit in the size of the atoms. The atoms hold the energy together, in a way, each atom representing a certain finite material quantum which can move only as a whole, and the larger the atoms the less can the total energy of motion be subdivided. This is quite in accordance with classical theory, but according to this the disintegration should proceed without limit in the case of the repeated reflection of light waves within a hollow enclosure—the infra-red and visible rays should gradually disappear and become converted ultimately into invisible ultra-violet or chemical rays. But of such a phenomenon no trace is discoverable in Nature. The conversion here also attains sooner or later a perfectly definite and assignable limit, and after that, the radiation conditions remain stable in every respect. The old theory proved untenable, but the principles of thermodynamics have shown themselves to be unshakable. The only solution of the riddle appears to be that, even in the case of the immaterial light and heat rays, certain processes must be at work which hold together the energy of radiation in definite finite quanta, and unite it the more strongly the shorter the waves, and the greater therefore the oscillation frequency. In what way we are to conceive the nature of merely dynamical quanta we cannot yet say for certain, but the hypothesis has certainly led to the idea that there are changes in nature which occur, not continuously, but explosively. Moreover, the Quantum Hypothesis affords solutions of still more recent discoveries which are in conflict with the classical theory, *e.g.* of the observed fact that to raise a piece of copper through one degree at -250°C . requires only about one-thirtieth of the heat required to raise it through one degree at 0°C ., and that if we took the original temperature of the copper still lower, the corresponding quantity of heat would turn out many times smaller, without any assignable limit. The Quantum Hypothesis has also led to the most important result that the forces controlling the thermal oscillations in a solid are of the same kind as those which control its elastic oscillations, enabling us to calculate the thermal energy of a monatomic substance at various temperatures from its elastic properties, a performance far beyond the reach of the classical theory. Puzzling though the nature of dynamical quanta may be, it is difficult to doubt their existence, in some form or other. For whatever we can measure must exist.

G. W. DE T.

1796. *Does Matter displace Ether?* C. V. BURTON. (Phil. Mag. 27. pp. 848-852, May, 1914.)—The author showed in a previous paper [Abstract No. 415 (1909)] that if the motion of matter through the ether involves displacement of the latter by the former, as in the case of a body moving in a fluid, then forces should be called into play between neutral bodies moving

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through the ether, unless their motion through the ether is simply a question of transference, and involves nothing of the nature of a gross bodily displacement. It is here shown that if there be finite displacement, a flat plate moving uniformly in a constant direction through the ether would tend to set itself with its plane perpendicular to that direction, being acted on by a couple whenever its normal was oblique to the line of motion. A convenient way to test the existence of such displacement is, therefore, to suspend such a plate by a fine fibre so that its plane is vertical, and to watch for any changes of azimuth which may occur as the earth's rotation causes the suspended system to be presented in varying aspects to the earth's line of motion. Very delicate apparatus was constructed, and is described in detail, consisting essentially of a thin iridio-platinum plate with a bi-filar quartz fibre suspension, having an optical system of extreme delicacy for observations of any motions in azimuth, and provided with elaborate protection against the various possible disturbing effects. Semi-diurnal and diurnal terms occur in the expression for the amplitude, from which the corresponding amplitudes of the semi-diurnal and diurnal turning moments about the vertical axis are obtained, and limits can be named which these certainly did not exceed with the apparatus used, on the least favourable assumptions as to the sun's unknown motion through the ether. No positive results were observed, and the determined limiting values of the possible turning moment therefore lead to a maximum possible value for the displacement if it exists. Taking Lodge's estimate of 10^{19} gm. per cm^3 as the minimum density of the ether, it follows that 1 gm. of matter occupies numerically less than $\pm 8.1 \times 18^{-17} \text{ cm}^3$, and probably less than $\pm 10^{-17} \text{ cm}^3$. The double sign signifies the consideration of the possibility that the density of the ether might conceivably be either diminished or increased by the presence of matter. The conclusion may also be expressed in the form that the displacement must certainly be less, probably much less, than what we designate the "bulk" of the electrons.

G. W. DE T.

1797. *Relativity and the Ether*. L. Page. (Amer. Journ. Sci. 88. pp. 169-187, Aug., 1914.)—The author's aim is to show that all electro-dynamic phenomena—those relating to accelerated charges as well as those involving charges moving with constant velocity—may be expressed in terms of an ether consistent with the Principle of Relativity, and as necessary consequences of the postulate of the relativity of all systems which are moving with constant velocities. An expression is also derived for the electro-magnetic mass of an electron whose field is not quasi-stationary, as in the case of Abraham's, Bucherer's and Lorentz's electrons.

The Lorentz-Einstein group of homogeneous linear transformations, as the mathematical formulation of the Principle of Relativity, is taken as the starting-point. An absolutely homogeneous ether satisfies the principle, but non-homogeneities are necessarily involved in interactions of material particles. And the ether will still satisfy the Principle if all such non-homogeneities are transmitted with the velocity of light, this velocity being an invariant of the transformations. Let these non-homogeneities, which may be called strains, be completely representable by a single-valued vector function E of position in space, having the properties that at any point the product of the volume element dr and the divergence of E must be proportional to the charge in dr , and that the charge must be an invariant for the fundamental transformations. Then $\text{Div } E$ will be zero in ether devoid of matter, and every charged particle will

be a continuously-emitting source of strains. One further assumption, suggested by symmetry, is found to be necessary, viz. to an observer to whom the charged particle is, instantaneously, at rest the strains must be emitted uniformly in all directions. The number of assumptions is here reduced to half the number involved in Lorentz's equations of electro-dynamics. The strains are represented geometrically by means of tubes of strain. Considering first a charge permanently at rest relative to the observer, which will now be regarded as a continuously-emitting source of strains moving outward through the ether with the velocity of light instead of, as in former theories, being surrounded by a uniformly diverging field of stationary strains. But the direction of motion being always parallel to the strain, the number of tubes of strain per unit cross-section will be constant, as in former theories, and the energy density at any point, if varying as the square of the strain, will remain constant. The total energy of the field will therefore be finite, and it becomes obvious that emission of strain does not necessarily involve emission of energy. The effect of a moving charged particle is first discussed, using Gibbs's vector notation. The ether strain equations are obtained first for a single charged particle, and the general equations are then derived by the considerations that the total ether strain is the vector sum of the strains due to all the particles whose fields extend to the point in question. An expression is obtained for the mass of an electron which has had a constant acceleration relative to its own system for an infinite time. In conclusion, the author points out that his method of finding the retarding force due to the electron's own field does not explain, any more than Lorentz's original treatment did, why the mutual repulsion of the parts of the electron does not cause it to explode. [See Abstract No. 1896 (1912) and G. A. Schott, "Electromagnetic Radiation," p. 262 *et seq.*] G. W. DE T.

1798. *Influence of Radiation on the Formation of Cloud.* C. Braak. (Meteorolog. Zeitschr. 81. pp. 275-279, June, 1914.)—When a cloud is cooled by radiation more rapidly than the surrounding air, it will sink by reason of its increased density. If the normal rate of decrease of temperature with height prevails, this sinking will cause the cloud to evaporate on account of the dynamical warming produced. It is only when the rate of fall of temperature is very slight, or when a reversal occurs, that the initial cooling is followed by further formation of cloud. If, on the other hand, the cloud is absorbing radiation instead of emitting it, the opposite results hold—namely, that if the fall of temperature with height is normal, the rising of the cloud consequent upon its warming will cause further cloud to be formed. The gradient of temperature must either be very small or reversed if the warming eventually results in the evaporation of the cloud. In the paper the above statements are proved, and the critical small temperature gradient referred to is shown to be about $0.18^{\circ}\text{C. per } 100\text{ m.}$ Instances of the application of the general result are given from observations made in Batavia during anticyclonic weather. R. C.

1799. *Principia Atmospherica : a Study of the Circulation of the Atmosphere.* W. N. Shaw. (Roy. Soc. Edinburgh, Proc. 84. pp. 77-112, 1913-1914.)—The author arranges our knowledge of meteorology, particularly that part of it relating to the upper air, in logical form with axioms, postulates, and propositions. Five axioms, or laws, of atmospheric motion are put forward, followed by two lemmas, or postulates, and six propositions. The whole argument is based fundamentally on the first axiom, which states that in the upper

air the true wind and the "gradient" wind are identical; that is, the upper wind blows along the horizontal sections of the isobaric surfaces, and the velocity is inversely proportional to the distance between consecutive isobaric lines. The two lemmas contain statements of facts which have been established in recent years by upper-air research. The chief part of the paper is devoted to consideration of the propositions. In proposition 1 it is pointed out that while a steady uniform E. or W. wind covering a large area represents a stable condition in the atmosphere this is not so in the case of N. or S. winds. It is found by calculation that a south wind will tend to increase in vertical thickness as the air passes northward, and steady conditions over a large area require that a certain quantity of excess air should pass out sideways in the lowest kilometre layer of the current. This condition can be fulfilled in practice, and hence there is no insuperable difficulty in accounting for a persistent south to north current. The converse case of north to south wind requires a more complicated system of currents to allow of a steady persistent state, and it is concluded that the maintenance of a northerly current must be regarded as exceptional. Attention is specially directed to the conclusion to which this reasoning leads: That a steady state of persistent motion in the earth's atmosphere is in the highest degree improbable, because it can only occur in a combination of circumstances which are independently fortuitous. The next most important proposition is that which deals with the calculation of the horizontal temperature gradient which must exist in different levels to account for the changes in wind velocity from kilometre to kilometre found by pilot balloon ascents. The formulæ here worked out are applied to several typical cases. The last of the six propositions deals, in a more general manner, with the general circulation of the atmosphere over the northern hemisphere.

J. S. DI.

1800. *The Transmission of Terrestrial Radiation by the Earth's Atmosphere in Summer and in Winter.* F. W. Very. (Science, 40. pp. 417-424, Sept. 18, 1914.)—The method employed to determine the percentage transmission of terrestrial radiation through the atmosphere consisted in comparing the actual radiation from a surface at the earth's temperature toward the sky with that toward a black body the temperature of which could be varied. By this means it was found that the radiation from a surface at $+18^{\circ}\text{C}$. (summer earth temperature) to the sky overhead was, with a clear sky, the same as to an efficient radiator at -8°C . This -8°C . is termed the "Effective temperature of the zenithal sky" under the conditions named. Taking these figures it is determined that the outward *unabsorbed* terrestrial radiation amounted to 0.57 gm.-cal. per sq. cm. per min. and the earth's radiation *to free space* to 0.15 gm.-cal. This gives a transmission of 26% for summer. In the same way a transmission of 68% is found for a clear winter day, when the air is more free from dust than in the summer. A. Ångström has found 0.15 gm.-cal. for an average value of the earth's radiation, which agrees with the above summer value. Lowell, on the other hand, who determined the transmission from consideration of the nocturnal cooling of the earth's surface with clear and cloudy skies, found a value some 50% larger than that determined by the present method. A suggested explanation of this discrepancy is put forward.

J. S. DI.

1801. *Weather-cycle Periodicities by Newcomb's Method.* A. Schuster. (Roy. Soc., Proc. Ser. A. 90. pp. 849-855, July 1, 1914.)—The author discusses the analytical method devised by Newcomb for the investigation of periodicity.

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cities, which was intended to give more complete values than the usual Fourier's analysis. A particular case is given in illustration, the data examined being the meteorological records collected by Brückner. The main conclusions are (1) that Newcomb's method is only applicable to special cases, the results obtained being in general difficult to interpret. (2) When it is applied to the 85-year Brückner cycle it does not lend any support to the reality of that cycle, although it seems specially adapted to deal with that type of periodic fluctuation.

C. P. B.

1802. Influence of Weather Conditions upon the Amounts of Nitric Acid and of Nitrous Acid in the Rainfall near Melbourne, Australia. V. G. Anderson. (Chem. News, 110. p. 127, Sept. 11, 1914. Paper read before the British Assoc., Australia Meeting, 1914.)—Daily observations of the amounts of nitric acid and of nitrous acid in the rainfall have been made for over a year at Canterbury, near Melbourne. The concentration of nitric acid reached a maximum in summer and of nitrous acid in winter. The ratio of nitric nitrogen to nitrous nitrogen was highest in summer and lowest in winter. On many occasions in winter the ratio was approximately as 1 : 1. It appears that in rain-water nitric and nitrous acids are formed in equal molecular proportions. In the hot weather of summer the nitrous acid is rapidly converted into nitric, whereas in winter the conversion goes on less rapidly. The facts point to atmospheric nitrogen peroxide as the source of nitric and nitrous acids in rain water. It is found that the amount of oxidised nitrogen per acre carried down by rain falling on any day is a function of the type of weather, but within certain limits is independent of the amount of rainfall. These facts may be explained by assuming that for each type of weather there exists in the air a definite concentration of nitrogen peroxide, and that this soluble gas is completely washed out of the air by the first portions of a shower. J. S. D.

1803. Investigation of the Oscillations of Tank-water. K. Honda and T. Matsushita. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 8. pp. 181-148, 1918.)—The paper contains an investigation of stream lines in flowing water by means of Honda and Terada's photographic method for studying the oscillations in the model of a bay. The method consists in scattering a fine aluminium powder over the model, and taking photographs of the oscillating water by exposing the dry-plate about one complete period of oscillation. After development, the stream lines are seen in the loop of the horizontal motion, while in its node the powder appears in points, so that the actual mode of oscillation of water in the tank can be perceived from the photographic plate. A square, a circular, an annular, and an equilateral triangular tank were studied, these being of zinc and placed on a board resting on stout india-rubber tubes to admit of easy oscillations. The oscillation was generally excited by a vertical rod, fixed at its lower end to the tank and carrying a weight which could be adjusted to a suitable height for varying the oscillation period. To maintain the rod's vibration, a piece of soft iron was attached to its lower part, and an electromagnet placed near it. An electric circuit including the electromagnet was so arranged that it was closed once during every rod vibration. If the period of the rod approaches to that of the water in the tank, the amplitude of oscillation of the water is greatly increased, a beat of oscillation being observed for approximate coincidence and a prolonged energetic one for exact. The period of free oscillations, after the oscillating cause was withdrawn, was observed by means of a stop-watch, taking the mean of 10 sets of about 50 complete oscillations. In the case of

the circular and annular tanks, a symmetrical mode of oscillation was excited by means of a lever, by applying a periodic motion to the centre of the base from beneath. The hydrodynamical solutions of these various tank-motions are briefly summarised, and tables of calculated and observed periods given.

No less than 44 admirable photographs are included.

H. H. Ho.

1804. *Secondary Undulations of the Canadian Tides.* **K. Honda and W. B. Dawson.** (Sci. Reports, Tôhoku Univ., Sendai, 1. No. 1. pp. 61-66, 1912.)—Six years ago, Honda with others investigated the secondary undulations of the oceanic tides on the coasts of Japan [see Abstract No. 400 (1908)], and found that the regular and conspicuous undulation in any bay is generally the standing oscillation having the node of its vertical motion at the mouth of the bay and its loop at the head. The period T of such an oscillation is fairly given by $T = 4l/\sqrt{gh}$, where h is the mean depth, and l the length of the bay measured normally to the contour lines of its bed. In an elongated bay there may exist the oscillation with 2, 3, 4, . . . nodal lines, and also in a few cases lateral oscillation in the bay. The exciting waves seem to originate in the open ocean, where wide undulations of various periods must apparently exist. From these the bay selects an undulation of the period which corresponds with its own dimensions in accordance with the above formula. The present paper refers to the undulations recorded on mareograms from five bays on the coasts of Canada: Sidney, Trepassey, Port aux Basques, Halifax, and SW. Point (Anticosti), all of which show conspicuous secondary undulations. The data obtained confirm the above views regarding the secondary undulations of the oceanic tide. These undulations are much accentuated in stormy and broken weather, showing apparently that the oceanic undulations from which they are propagated are probably due originally to meteorological causes. The Canadian observations also show that these secondary undulations disappear in long estuaries such as the St. Lawrence, analogous to the breaking up of the ocean swell under similar conditions.

H. H. Ho.

1805. *Recent Physical Investigations in the North Atlantic Ocean.* (Nature, 98. pp. 541-548, July 28, 1914.)—This article is a review mainly of F. Nansen's investigations of 1910 as detailed in his oceanographical work entitled "The Waters of the North-eastern North Atlantic."

L. H. W.

1806. *Equatorial Acceleration of Solar Rotation.* **G. Meslin.** (Comptes Rendus, 158. pp. 1560-1562, June 2, 1914.)—The author disagrees with the interpretation of certain of the conclusions formulated by Cornu concerning the peculiarities shown by spectrum lines when the spectroscope slit is adjusted at various angles on the sun's disc. The fact that the rotational velocity rapidly varies with the distance from the equator is regarded as sufficient to produce certain of the phenomena seen as distortions of the spectrum lines.

C. P. B.

1807. *Measurements of Solar Radiation.* **L. Gorczynski.** (Nature, 98. pp. 862-868, June 4, 1914.)—The paper is a short review of observations made during the thirteen years 1901-1913 at Warsaw, using actinometers and pyrheliometers. They have an interesting bearing on the peculiar variations of the solar radiation during 1912, which have been ascribed to the effect of volcanic dust from the eruption of Mt. Katmai, in Alaska, at the end of June, 1912. For the earlier months of 1912 the radiation was higher than the

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average, but from July to the end of the year it was nearly 20 % below the average. The deficiency apparently disappeared in the second quarter of 1918. The results of the inquiry are discussed very fully with respect to different altitudes of the sun, times of day, and different conditions of the atmosphere, especially as regards humidity. C. P. B.

1808. Determination of the Solar Constant by means of Computations based upon the data of Balloon Ascents. F. H. Bigelow. (Amer. Journ. Sci. 88, pp. 277-281, Sept., 1914.)—The value of the solar constant, as derived from pyrliometer observations, is about 2 gm.-cals./cm.² min. Abbot's observations on the spectrum energy curve are, however, best satisfied by an initial effective temperature of the sun of about 6900°, which leads to a value of 4 gm.-cals./cm.² min. for the solar constant at the distance of the earth. The author, using temperature and pressure observations up to 25 to 80 km., comes to the conclusion that the true solar constant (A) is 4, and that the "effective radiation" (I), measured by a pyrliometer is $A - J - B$; where J is the radiation emitted from the earth's surface, while B is the "return radiation," and is equal to I during steady temperatures. J varies from about 1.5 at the surface to zero at 40,000 metres, and for steady temperatures $I = \frac{1}{2}(A - J)$, which is 1.25 at the surface and 2 above 40 km. At night, $I = B = A = 0$, and the nocturnal radiation proceeds from J only. R. C.

1809. Sky Polarisation and Solar Constant. A. Boutaric. (Comptes Rendus, 158, pp. 1600-1602, June 2, 1914.)—An investigation was made to determine the effect of polarisation of the diffuse light of the sky on the values obtained for the solar constant. It is shown that for groups of neighbouring days, the value of the solar constant varies inversely as the sky polarisation. C. P. B.

1810. Solar Spectrum and the Earth's Crust. H. N. Russell. (Science, 39, pp. 791-794, May 29, 1914.)—A comparison is given of the list supplied by Rowland showing the chemical elements represented in the Fraunhofer solar spectrum, and the table of Clarke showing the percentage composition of the outer 10 miles of the earth's crust, including the lithosphere, hydrosphere, and atmosphere. The average composition of stony meteorites is also added. The lists are very similar. One of the interesting differences is in the case of potassium, which is very abundant in the earth's crust, but there is some doubt as to its presence in the sun. C. P. B.

1811. Variation of Heat Radiation in Atmosphere of Mars. M. Milankovitch. (Ann. d. Physik, 44, 8, pp. 465-476, May 26, 1914.)—A long analysis is given to obtain a value of the diminution of heat radiation through the Martian atmosphere, and the results are compared with the glasshouse or accumulative theory. C. P. B.

1812. Temperature of Planets. F. Vercelli. (Accad. Sci. Torino, Atti, 49, 5a, pp. 298-325, 1918-1914.)—Shows on general grounds that the age, temperature, and thermal gradient of planets, calculated by Fourier's method, must be considered as minimum values. Applying the method on a wider range to spheres, and using elliptic functions, the author deduces 187 million years as the minimum time since solidification began. The absolute temperature at the centre after the same period rapidly increases with the diameter of a planet, being 0° in the case of Eros, 40° in the case of Juno,

2000° for Vesta, and 4000° for all planets from the size of the moon upwards. This supposes that the physical structure of the planet is similar to that of the earth. The temperature gradient would thus be of the order of that of the earth for the larger planets, but would be very low for the planetoids.

E. E. F.

1813. *Statistics of Satellite Orbits*. J. Delauney. (Comptes Rendus, 158. pp. 1405-1407, May 18, 1914.)—Investigating the periods of revolution of the satellites of Saturn, the author finds the relation that their second differences are in the ratio of the progression 1 : 8 : 9 : 27 : 81

C. P. B.

1814. *Numbers of Stars in Different Galactic Latitudes*. S. Chapman and P. J. Melotte. (Roy. Astronom. Soc. Memoirs, 50. Part 4. pp. 145-178, 1914.)—The investigation aims at providing a reliable estimate of the number of stars classified according to their apparent brightness and position in the sky. Counts were made for selected regions on photographs taken with the Franklin-Adams camera, and formulæ are developed by means of which the star density down to any magnitude and galactic latitude may be deduced. The results are tabulated in four galactic groups.

C. P. B.

1815. *Spectroscopic Binaries and Velocity of Light*. R. S. Capon. (Roy. Astronom. Soc., M.N. 74. pp. 507-517, April, 1914.)—Michelson having recently shown that the velocity of light is unaffected by reflection at a moving mirror [Abstract No. 1265 (1913)], it was of interest to investigate the possibility of the velocity being affected in the case of motion of the light source—for example, in the component stars of spectroscopic binaries. From a study of the distribution of periastra of such systems it is concluded that any effect of the velocity of the source on the velocity of light is certainly very small. There is some tendency to systematic grouping of the periastra which needs investigation.

C. P. B.

1816. *Variable Star VV (17-1912) Aurigæ*. H. G. S. Barrett. (Roy. Astronom. Soc., M.N. 74. pp. 588-540, April, 1914.)—The variability of this star was detected during the examination of photographic plates taken with the 24-in. refractor at Radcliffe Observatory, Oxford. A table is given showing the observations from 1912 Jan. 26, to 1914 April 6, and a drawing of the determined light-curve, indicating a period of 416 days.

C. P. B.

1817. *Total Light of the Stars*. S. Chapman. (Roy. Astronom. Soc., M.N. 74. pp. 446-451, March, 1914.)—Utilising the data collected in a series of counts of stars on photographic records, classified according to their Harvard photographic magnitudes down to 17.0, in various galactic latitudes, the analysis leads to the conclusion that the total light of all the stars is equal to that of 681 stars of the first magnitude. Various corrections are applied which alter this to the equivalent of 690 stars of the first magnitude for the total light of all stars. This being in terms of the photographic standard, it is also given as equivalent to 900 or 1000 on the visual scale, as the photographic magnitude of the average star is numerically greater than the visual magnitude.

C. P. B.

1818. *Constitution of Nebulæ*. J. W. Nicholson. (Roy. Astronom. Soc., M.N. 74. pp. 486-506, April, 1914.)—A definite theory is presented to account for the chemical constitution of nebulæ, based on the discussion of the VOL. XVII.—A.—1914.

nebular spectrum on the electronic hypothesis. The average spectrum appears to show the presence of (a) The various simple ring-systems, with simple nuclei, showing only spectral lines which are apparently distributed at random. (b) The first products of some form from these systems which leads ultimately to the Wolf-Rayet stars, in which series analogous to the terrestrial spectral series may be found. (c) Hydrogen and helium, the simplest terrestrial elements, the former of these being included in (b). It is thus concluded that the chemical substance of the nebulae consists of the beginning of matter; the electrons not being held very firmly in the atoms, permitting a continual interchange of electrons, with a necessary bombardment of atoms by free electrons, to which the luminosity is probably due. The physical state of a nebula might thus be compared to that in a very exhausted vacuum tube of enormous extent.

By the consideration chiefly of neutral atoms many nebular lines have been accounted for by the analysis. C. P. B.

1819. *Radial Velocity of Orion Nebula.* H. Bourget, H. Buisson, and C. Fabry. (Comptes Rendus, 158. pp. 1269-1271, May 4, 1914.)—A series of photographs of the Orion nebula have been made with the interferential spectrometer, using a difference of path of 2 mm. in the étalon, from which the radial velocities of different parts of the structure have been determined. The mean velocity of the nebula with respect to the sun is given as +15.8 km. per sec., indicating a motion away from the solar system. The various subsidiary motions observed suggest a type of rotation about the axis passing SE. and NW. By comparison with terrestrial spectra the actual wave-lengths of the components of the strong ultra-violet nebula line have been determined to be $\lambda 8726.100$ and $\lambda 8728.888$. C. P. B.

1820. *Atomic Weight of Elements in Nebulae.* J. W. Nicholson. (Comptes Rendus, 158. pp. 1822-1823, May 11, 1914.)—From the analysis representing the element nebulium as consisting of a central positive nucleus with four electrons in the encircling ring, the atomic weight of this system would appear to be 1.81. What the author calls protohydrogen is assigned an atomic weight of 0.0818, and archonium, represented by the ultra-violet lines, a weight of 2.945. C. P. B.

LIGHT.

1821. *Polarising Prisms for the Ultra-violet.* S. S. Richardson. (Phil. Mag. 28. pp. 256-268, Aug., 1914.)—Requiring a beam of polarised ultra-violet rays, the author found that the prisms employed transmitted no light of higher refrangibility than about 8000 \AA.U. The polariser and analyser were both large prisms of the Foucault type, and, since Iceland spar is quite transparent as far as $\lambda 2140$, the want of transmission was due obviously to the reflection of the extraordinary ray, as well as the ordinary, at the air-film. In view of this the author has determined the limiting values of the angles of inclination of the air-film for transmitting polarised beams of short wavelength for the cases of: (1) A square-ended Foucault, the end faces being perpendicular to the line of vision, and to the planes containing this line and the optic axis; (2) an ordinary Foucault, the end faces being the natural ends of the crystal; and (3) a Glan-Foucault prism. Tables of results are given. The angular diam. of the polarised beam is found to be much increased by the use of a suitable cement for the two halves of the prism. Canada-balsam is inadmissible in ultra-violet work, as even in thin films it arrests all rays beyond $\lambda 8400$, but liquids such as castor-oil and glycerine can be used. The author hopes to deal with cemented prisms in a later paper.

H. H. Ho.

1822. *Measurement of Cloudiness.* W. Mecklenburg and S. Valentiner. (Zeitschr. Instrumentenk. 84. pp. 209-220, July, 1914.)—Describes an apparatus, devised by the authors and termed by them a Tyndallmeter, which, by the method of Tyndall's experiment to imitate the blue colour of the sky, gives a measure of the cloudiness of any substance (solid, liquid, or solid particles suspended in liquid). One portion of a horizontal beam of light from a Nernst filament traverses the substance under investigation in the interior of which part of it is scattered upwards and illuminates one face of a Lummer-Brodhun photometer head. The remainder of the beam is reflected from a plaster surface, and after traversing three Nicol prisms in succession illuminates the other surface of the Lummer-Brodhun head so that the intensities of the two portions of the beam may be compared. The second of the three Nicol prisms is capable of an accurately measurable rotation while the other two remain fixed with parallel axes. By this means any desired dimming of the light traversing the prisms may be obtained, and if ϕ is the angle of rotation of the middle prism from the crossed position, the intensity of the beam is proportional to $\sin^4 \phi$. The effect of simple absorption of the beam by the substance is eliminated by taking several observations in positions at which the beam traverses different thicknesses of the substance. The effect at zero thickness is then obtained graphically by extrapolation. This is done for the effect of absorption on (a) the original beam before scattering takes place, and (b) the scattered light. As examples of the uses to which the instrument may be put, and of the method of experiment, detailed accounts of experiments on uranium glass, white of egg, silver chloride suspended in water, and Zsigmondy's red colloidal gold solution are given. Of particular interest are the similar experiments on town waste-water both before, and after various stages of, filtration. As a useful addition to the instrument there is included

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an arrangement of prisms by means of which the beam of light traversing the substance may be shifted parallel to its original direction, in order to investigate the brightness of the substance at any given distance from the exciting beam. The description of the apparatus is illustrated by two clear diagrams and a sketch of the complete instrument. J. W. T. W.

1923. Transmission and Reflection Photometer for Small Areas. P. G. Nutting and L. A. Jones. (Washington Acad. Sci., Journ. 4. pp. 818-815, June 19, 1914. Communication No. 15 from Research Lab. of Eastman Kodak Co.)—In many optical investigations it is desirable to measure the brightness of areas 1 mm. square or less. The instrument here described was devised for measuring the brightness of optical images, the local densities in photographic negatives and the reflecting powers of photographic prints. It is stated to have proved exceedingly convenient and precise, and to be easily, quickly, and permanently adjustable. For months it has been in constant use by a number of observers for sensitometry of photographic plates and papers. With a magnifying ocular it has even been used as a microphotometer of low power. The chief advantages claimed are: (1) Elimination of errors due to fluctuation in the comparison source by making the same light serve for both sources. (2) Elimination of corrections for shift of zero by providing easy means of balancing the two beams with an open system. (3) Direct view of the object sighted upon at all times during measurement. This is obtained by focusing an image of that object at the dividing line of the photometer cube. (4) An open linear scale, reading directly from zero to 100 %, provided by a rotating comparison beam and stationary sector. The photometer head used is, in fact, that of the Bechstein illuminometer. The source of light E is a condensed filament 100-watt tungsten lamp run on the lighting circuit. One beam of light from the source travels in a direct path through a comparison screen of thin solid opal glass, a stationary sector S, a rotating excentric lens L, and a photometer cube P, to the ocular O. Another beam from the source E travels to the photometer cube P in a path forming three sides of a rectangle ER_1R_2P , with reflecting prisms at the corners R_1R_2 . The first reflecting prism R_1 is inside a metal box mounted on a stand. The front face (at which the beam emerges) of this box is a plate of flashed opal glass D, which serves as a secondary source by diffusing the light. The plate whose transmission is to be determined is placed directly in front of this diffusing screen, thus eliminating errors due to diffusion in the transmission measured. An image of this observed plate is thrown on the photometer cube P by means of the second reflecting prism R_2 , and a lens placed between R_2 and P. This lens (which is adjustable in position), and the prism R_2 , are mounted on an arm carried by the instrument. In use, before inserting the plate to be measured, the sector S is first set to read 100, and the source E moved to and fro until a balance is secured. The instrument will then read percentage transmission from 0 to 100 %, with very slight zero correction. For determining reflecting powers, R_1 and D are not used, and R_2 is rotated to face downward instead of horizontally. The surface to be measured is placed directly under R_2 on the table, and illuminated directly by the source E at about 45° . If only relative values are desired, clear paper is placed in the field, the sector set to read 100 %, and the source E adjusted to give a match at the cube. If actual reflecting powers are desired, a matt surface, say a block of magnesium carbonate, whose reflecting power has been determined on an absolute reflectometer, is placed in position, the sector S set to read its absolute

reflecting power, and the source E adjusted as before. The instrument will then give directly the diffuse reflecting power of any other surface placed in the field.

A. E.

1824. Registering Microphotometer for Laboratory Spectra. A. S. King and P. P. Koch. (Astrophys. Journ. 39. pp. 218-229, April, 1914. Contribution from the Mount Wilson Solar Observatory, No. 77.)—A preliminary study has been made of the application of the microphotometer in registering the distribution of photographic density over the width of spectrum lines. It is found that a quantitative measure is obtained of the relative strengths of lines having very different appearance, especially the sharp and diffuse lines often occurring in the same spectrum, when the max. density of the line cannot be taken as a measure of its intensity. It is also applicable to determine the characteristics of lines given by the electric furnace at different temperatures. The intensity curves for electric-furnace lines when displaced by pressure show that a line, if originally sharp, may maintain a structure very nearly symmetrical through a wide range of pressure. This indicates that the pressure effect does not appear to be the result of unsymmetrical widening, and the symmetry of reversals is further evidence of a lack of dependence on temperature or vapour density.

C. P. B.

1825. Crystallography. F. Canac. (Comptes Rendus, 159. pp. 405-408, Aug. 10, 1914.)—Describes a new method of making crystallographic measurements by means of Röntgen rays. Utilising the experiments of Laue and Terada [see Abstract No. 1160 (1918)] it is found possible, from a study of the manner in which the spots are displaced when a crystal is made to turn about certain axes (normal to the fundamental section), to construct the lattice and to calculate its parameters. Measurements were made on a sugar crystal, and results were obtained in close agreement with those obtained by Wolff by ordinary optical measurements. [Errata. Ibid. p. 516, Sept. 21, 1914.]

A. W.

1826. Refractive Index and Density. I[rene] M. Mathews. (Frank. Inst., Journ. 177. pp. 678-686, June, 1914.)—This paper gives a descriptive account of the deduction and testing of the three chief equations connecting these properties, viz. (1) $(\mu^2 - 1)/d = \text{const.}$, (2) $(\mu^2 - 1)/(\mu^2 + 2)d = \text{const.}$, and (3) $(\mu - 1)/d = \text{const.}$ The sum-total of the evidence points to the general validity of the latter two, and for low densities both relationships appear to be equally good. Some doubt, however, remains as to whether (2) or (3) holds when the temperature is varied, and this point has now been tested for oxygen with a Fabry and Perot interferometer. An arrangement is described by which the difference between the laws (2) and (3) at pressures of about 8 atmos. can be detected.

C. S. G.

1827. Enclosed Cadmium Arc. T. M. Lowry and H. H. Abram. (Faraday Soc., Trans. 10. pp. 108-106, Aug., 1914. Chem. News, 109. pp. 171-178, April 9, 1914.)—Describes a cadmium arc of the enclosed type for use in polarimetric work. The arc is run between water-cooled electrodes of solid cadmium, because if the metal is allowed to melt it is liable to crack the tube whenever the lamp is started or stopped, and with solid electrodes there is less vaporisation of the metal. The electrodes are contained in two side-tubes sealed into a horizontal tube near its middle point, and this horizontal tube is provided with quartz windows at the ends. In the most

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recent form of the lamp the ends of the horizontal tube are provided with water-jackets to prevent as much as possible the condensation of metal on the quartz windows, but the water-jacketing must not extend to the central part of the tube, which must remain hot in order to prevent the formation of a conducting bridge of condensed metal. An arch of silica between the two side-tubes containing the electrodes serves to bring the arc to the centre of the tube. The lamp must be used in conjunction with a Gaede pump, as the metal gives off considerable quantities of gas under the influence of the electric discharge. Occasionally, when the vacuum is good, the arc will start itself when the current is switched on, but usually it is necessary to start the arc by a spark. An example of the use of the lamp is given in the case of α and β -methylglucoside. It was desired to find not merely the magnitude of the constants in the dispersion equation, but also whether these two compounds, containing no less than five asymmetric carbon atoms, nevertheless obeyed rigidly the simple dispersion law. The results show that the readings taken with the green and red Cd lines are quite as reliable as those taken with the violet and green Hg lines for working out the rotation constant k and the dispersion constant λ_0^2 for either substance. It was found that the simple dispersion formula very accurately represents the experimental data for the α -methylglucoside. The readings for the β -methylglucoside are not so concordant, in part because they are 5 times smaller; but they agree sufficiently well to show there is no large deviation from the simple dispersion law.

The development of the enclosed Cd arc promises to inaugurate a new era in the measurement of simple rotatory dispersion. With the help of the new apparatus it will be possible to determine the two fundamental constants of any optically active compound by two methods of equal exactness. Further, the agreement of the two pairs of figures will serve as a check, not merely on the accuracy of the readings, but also on the strict validity of the dispersion formula in the case of each individual substance. A. W.

1828. Simple and Complex Rotatory Dispersion. T. M. Lowry and T. W. Dickson. (Faraday Soc., Trans. 10. pp. 96-102, Aug., 1914.)—Recent investigations on the rotatory dispersion of light in quartz show that this cannot be represented, even within the limits of the visible spectrum, by Drude's simplified equation, $a = k_1/(\lambda^2 - \lambda_1^2) + k'/\lambda^2$ ("Theory of Optics," 1907, p. 418). Very satisfactory agreement between the observed and calculated values is obtained, over the whole range from a wave-length of 16740 to one of 2827 Å. units, by means of Drude's general equation with three terms, namely, one infra-red term and two ultra-violet terms: $a = k_0/(\lambda^2 - \lambda_0^2) + k_1/(\lambda^2 - \lambda_1^2) + k_2/(\lambda^2 - \lambda_2^2)$. In this equation λ_2^2 is 78·22, as given by Drude and λ_1^2 , a constant differing somewhat from Drude's figure, 0·010627, while λ_0^2 represents another wave-length in a remote part of the inaccessible ultra-violet region. Equally good agreement may, however, be obtained by replacing the whole of the infra-red term by a constant, putting $\lambda_0^2 = 0$ and regarding λ_1^2 as an unknown quantity, thus: $a = k_0/\lambda^2 + k_1/(\lambda^2 - \lambda_1^2) + k_2$.

For simple organic liquids the curves of optical and magnetic rotatory dispersion are expressed, within the limits of the visible spectrum, by the simple equation, $a = k/(\lambda^2 - \lambda_0^2)$. This fact does not, however, prove that these substances are characterised by only one natural period of free vibration, since the optical rotatory power of quartz—which is known to possess four such natural periods—can be represented within the same limits of accuracy by this simple formula. The anomalous rotatory dispersion of ethyl tartrate may be represented by a Drude formula containing two terms

of opposite sign, and photographic data obtained show that, as the limit of the visible spectrum is approached, the rotation changes in sign and the ester becomes strongly lævo-rotatory. The form taken by the equation in this case may be due to: (1) two vibrations of unequal period and opposite activity; (2) the superposition of two "partial rotations," or (3) the actual presence of two distinct substances. Dynamic isomerism as a cause of anomalous rotatory dispersion is discussed.

Instead of making a distinction between "normal" and "anomalous" dispersion, it would be more satisfactory to distinguish between simple rotatory dispersion, expressible by the equation, $\alpha = k/(\lambda^2 - \lambda_0^2)$, and complex rotatory dispersion, which requires an equation containing two or more terms, thus: $\alpha = k_1/(\lambda^2 + \lambda_1^2) + k_2/(\lambda^2 + \lambda_2^2) + \dots$ T. H. P.

1829. Pressure Shift of Zinc Spectrum Lines at Low Pressures. V. F. Swaim. (Astrophys. Journ. 40. pp. 137-147, July, 1914.)—This paper describes a continuation of the work of Gale and Adams [see Abstract No. 81 (1914)] on the effect of pressure upon arc lines. The pressures employed range from 5 cm. to 2.2 atmos., and photograms were made in the second order of a Rowland grating where the dispersion was about 1 mm. per Ångström. The region investigated extends from $\lambda 4811$ to $\lambda 8076$, and the results are tabulated in mean redward shifts (Δ) per atmosphere. Lines in the first and second subordinate series as well as non-series lines are examined, and on the basis of the classification of the former by Gale and Adams the relationships between λ and $\Delta\lambda$ are worked out. The displacement at a particular pressure of lines of the first subordinate series varies as $1/\lambda^3$ and of the second subordinate series as $1/\lambda$, whilst for non-series lines the displacement is directly as λ^2 . The first subordinate series line at $\lambda 2802.11$ behaves, exceptionally, as a non-series line. C. S. G.

1830. Absorption Spectrum of Zinc-vapour. J. C. McLennan. (Phil. Mag. 28. pp. 860-863, Sept., 1914.)—Wood and Guthrie [see Abstract No. 1215 (1909)] found no trace of any absorption with zinc-vapour in the range of the spectrum investigated by them, which began at about $\lambda 5200$ and apparently did not extend beyond $\lambda 2150$. In view of the prediction made by Paschen and subsequently confirmed by Wolff [Abstract No. 239 (1914)] that the emission spectrum of zinc should include a series of single lines with the first member of the series at $\lambda 2189.83$, it seemed desirable to look for absorption by zinc-vapour in the region below $\lambda 2150$. Some pure zinc was placed in a clear fused quartz tube 2 cm. in diam., which was then highly exhausted and sealed up. This tube was placed before the slit of a quartz spectrograph and heated with a Bunsen burner. When the spark between zinc terminals in air was used as the source of light, it was found that the vapour evolved when the zinc was melted and raised to a red heat was sufficient to cut out completely the line $\lambda 2189.83$. With this moderate heating the absorption band was sharp and quite narrow. With stronger heating, however, the band widened symmetrically, and with very strong heating with a Meker burner it could easily be made to cover a range of from one to two hundred Å. units. No trace of any other absorption was found either above $\lambda 2189.83$ or in the region of the spectrum below this line down as far as $\lambda 1840$. From observations on such factors as intensity, line structure, Zeeman-effect, and Doppler-effect, Stark has been led to take the view that the line $\lambda 2586.72$ belongs to the Hg single-line series, and that it is really the first member of that series; i.e. according to him the Hg line $\lambda 2586.72$ and VOL. XVII.—A.—1914.

not the Hg line $\lambda 1849.6$ is homologous with the Cd line $\lambda 2288.79$ and the Zn line $\lambda 2189.88$. Various considerations regarding absorption here advanced lend some support to this theory. Since the evidence adduced so far indicates that we should expect to find absorption by the vapours of Hg, Cd and Zn at $\lambda 1402.71$, $\lambda 1669.8$ and $\lambda 1589.64$ respectively, it suggests that the lines of Paschen's single-line series in the emission spectra of these three metals correspond to the system of electric vibrations which is most easily set up in the atoms. This would fit in with the view expressed by Stark that the lines of these three series are the ones which correspond to atoms of Hg, Cd, and Zn in the neutral state. A. W.

1831. *Wave-lengths of Hydrogen Lines and Determination of Series Constant.* W. E. Curtis. (Roy. Soc., Proc. Ser. A. 90. pp. 606-620, Sept. 7, 1914).—The author has determined in International units, with an accuracy of about 0.0001 \AA . the wave-lengths of the first six lines of the Balmer series of hydrogen. The Balmer series formula is found to be inexact, and instead the results may be represented by a modified Rydberg formula containing only two constants thus: $n = N4 / -N/(m + \mu)^2$, where $N = 109,679.22$ and $\mu = +0.0569$. For the measurements a 10-ft. concave grating was used, with which an accuracy of 0.001 \AA . in the third order is obtainable when exposures are short (under half an hour). With longer exposures it was found to be very difficult to obtain accurate determinations on account of the difficulty of controlling sufficiently the temperature variations of the instrument. As standards the tertiary iron arc lines determined by Burns were employed after their accuracy in the region investigated had been tested and found satisfactory. Full details are given in the paper of all the refinements tending towards accuracy, and the resulting measurements are tabulated with the former measurements of Rowland, Ames, Dyson, Evershed, and Mitchell. C. S. G.

1832. *Atomic Structure and Helium Spectrum.* J. W. Nicholson. (Phil. Mag. 28. pp. 90-108, July, 1914).—Bohr's theory of spectra, in spite of its very general assumption, fails for lithium and the heavier elements [Abstract No. 1246 (1914)]. It must therefore stand or fall by the extent to which it accounts for the spectra of hydrogen and helium. Now for all ordinary elements whose spectra can be put into series of Rydberg's approximate type, there are three main series, viz., where B is Rydberg's constant, and p, s, d are definite constants for the elements: Diffuse, $\nu = B [(1 + S)^{-2} - (m + d)^{-2}]$; Sharp, $\nu = B [(1 + S)^{-2} - (m + p)^{-2}]$; Principal, $\nu = B [(1 + p)^{-2} - (m + s)^{-2}]$. On Bohr's theory, these obviously require the existence of three different types of stationary types, to which the constants m, s, p are individually peculiar, and that the spectral series are formed during the passage of the atom, not between different states or configurations of the same type, but between different types of states. But if the He-atom contains only two electrons, with comparatively inert nucleus, the degrees of freedom are insufficient for three types—and the He spectrum contains six such series, with six apparently independent constants. Moreover, the He-atom, according both to Bohr's theory and J. J. Thomson's experiments, will not take up an extra electron, so that the neutral atom and the atom which retains only one electron are alone left to explain the entire spectrum. Now the author has shown [Abstract No. 1247 (1914)] that the observed He spectrum is not obtainable on the present form of Bohr's theory, and that none of the possible steady states of the two electrons leads to a formula approaching Rydberg's. It is found that for

more than one electron Bohr's theory must admit the additional hypotheses that : Nuclei attract bound electrons according to the inverse square law : Bound electrons do not mutually repel according to this law : The angular momentum of an electron may cease to be $\tau h/2\pi$, when τ is an integer, if there are other electrons present. Considering Bohr's Li-atom model of three electrons and a nucleus, the law of force of the second hypothesis is shown to be either—No force at all, or any law whatever, provided that the three electrons are in one ring. But the latter alternative cannot take account of the valency of lithium. Direct distance laws are formally possible for electrons on confines of nucleus—but these are just β -particles, and any combination of them with those of first hypothesis leads to Li-spectrum indistinguishable from that of H. Therefore the zero force hypothesis remains the only one ; and this can be generalised for any element, giving an atom in which any electron is acted on by the nucleus only, and behaving therefore as simply as the electron in a H-atom. Such an hypothesis is a step towards J. J. Thomson's conception of tubes of force in the atom.

Returning to the He spectrum, assumed to contain nucleus $2e$ and two electrons only, mathematical analysis shows that no possible law of electronic repulsion can lead to any He series corresponding with observation, and that even the abandonment of the hypothesis that τ is an integer, and its replacement in Bohr's expression for the angular momentum by $f(\tau)$, a function of an integer τ and also of the nuclear charge and the number of electrons in the atom, leads to the conclusion that—Bohr's theory cannot explain the He spectrum, or any other series spectrum, by any modification which will retain the simpler theory of H and the Pickering series, with or without force between bound electrons. And the argument can be extended to nuclei $8e$ and $4e$. The final conclusion, therefore, is that Bohr's theory cannot give the spectrum for any atom, and is incapable of further development in the interpretation of spectra.

G. W. DE T.

1833. *Effect of Self-induction on the Nitrogen Bands.* E. P. Lewis. (Astrophys. Journ. 40. pp. 149–153, July, 1914.)—The author has extended his former observations made in 1908 and 1906. Self-induction causes the appearance of negative bands everywhere, but the most striking changes are produced in the positive bands. In these latter, compared with the spectrum of the simple discharge or that of a small Tesla coil, self-induction and capacity produce a relative enhancement of the more refrangible lines belonging to the principal head so that they can be easily followed to the head of the next group. Sub-heads are almost completely suppressed and the lines are sharpened up considerably. The group extending from a head at $\lambda 8871$ is chiefly dealt with and the new lines revealed fit well into a Deslandres formula. There is reason to believe that this band is composite, all but the principal series being suppressed by self-induction.

C. S. G.

1834. *Ultra-violet Spectrum of Neo-ytterbium.* J. Blumenfeld and G. Urbain. (Comptes Rendus, 159. pp. 401–405, Aug. 10, 1914.)—In a previous paper the authors have described a method of obtaining neo-ytterbium. Tests of the paramagnetism of a series of consecutive fractions showed practical constancy, evidence that the separation was complete. Measurements have now been made of the arc spectra of the extreme fractions of this series. The spectra are identical with the exception of a few faint lines which have been identified with lines of thulium and lutecium. Wave-lengths of the lines (which range from $\lambda 2800$ to $\lambda 8500$), with remarks as to their sharpness and intensity, are given.

A. W.

1835. *Spectrum of Elementary Silicon.* W. Crookes. (Roy. Soc., Proc. Ser. A. 90. pp. 512-520, Aug. 1, 1914.)—Former workers have never made complete investigations of the spectrum lines of this element from the ultra-violet right to the extreme red. Moreover, their results show many differences, doubtless due to the varying degrees of purity of the specimens employed. Both these objections have been overcome, and the lines have now been mapped continuously from $\lambda 2124 \text{ \AA.}$ to $\lambda 6871 \text{ \AA.}$ Silicon up to 99.98 % purity was obtained from the Niagara Falls Carborundum Co., and utilised as electrodes with high-frequency current. Oxidation and pitting of the poles is overcome by frequent grinding on an emery wheel. In practically all regions records are obtained photographically and referred to the iron standard, but in the case of a few faint lines in the orange-red, eye observations are employed, and for this purpose a specially devised recording attachment is fitted to the eyepiece of the 5-prism spectrograph. C. S. G.

1836. *Red Lithium Line.* T. Takamine and K. Yamada. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 889-842, July, 1914.)—By photographing the absorption lines of $\lambda 6708$ of lithium Zeeman has shown that very probably this line is a doublet with $\Delta\lambda = 0.144 \text{ \AA.U.}$ The authors now show that the doublet can be obtained in the emission spectrum if a specially regulated brush discharge is utilised as light source in conjunction with a Hilger grating. A separation $\Delta\lambda = 0.165 \text{ \AA.U.}$ is found in the emission doublet. Several tests are applied to substantiate the true duplicity as distinct from mere reversal. This measurement of $\Delta\lambda$ reaffirms the exceptional behaviour of Li; for the value of the ratio of the difference of the oscillation frequencies between the doublet and the square of the atomic weight, which holds for all the other alkali metals, does not hold for Li. The character of the spectrum of the brush discharge is very different from that of the ordinary spark spectrum of the metal. C. S. G.

1837. *Spectroscopy of Secondary Röntgen Rays and their Absorption Spectra.* M. de Broglie. (Comptes Rendus, 158. pp. 1498-1495, May 25, 1914.)—When X-rays from a Röntgen bulb are allowed to fall on a metal, the latter will, if the rays are of the right hardness, give off its characteristic radiation. By exposing a body whose spectrum was required to the direct rays from a bulb and placing the spectroscope slit so as only to receive the secondary rays, the author has managed to obtain definite spectra. With brass for instance as radiator, and a crystal of rock salt turning at an angular velocity of about 7° to 8° per hour as reflector, a spectrum was obtained showing clearly the characteristic lines of the constituent elements of the brass. This arrangement has an advantage over that in which the metal acts as antikathode inside the bulb, in that it is quicker and less laborious.

Some experiments were carried out on the absorption of the rays. The absorbing screens are either placed just in front of the spectroscope slit or in front of the photographic plate to obtain the absorption spectra, but in order to get a clear well-defined spectrum the exposures have to be sufficiently prolonged. By interposing a sheet of Cu-foil, 0.01 mm. thick, between the radiator and the plate, an absorption band is observed in the spectrum which stretches from about $14^\circ 15'$ to 10° . This affords a confirmation of the fact stated by Barkla and Sadler, that elements possess in general a band of absorption for wave-lengths shorter than those of their characteristic rays. The author points out that the intense bands described in former communica-

tions [see Abstracts Nos. 675, 676, 1080 (1914)] as being present in all the spectra hitherto obtained, may be due to the fluorescence of the AgBr constituting the emulsion of the photographic film; the band in the region of the shorter wave-lengths would correspond to Ag and the other to Br. This interpretation appears to be a plausible one. E. A. O.

1838. *Direct Spectral Analysis of Secondary Röntgen Rays.* M. de Broglie. (Comptes Rendus, 158. pp. 1785-1788, June 15, 1914.)—In a previous communication [see preceding Abstract] the author described a method of obtaining the spectra of bodies without using them as antikathodes inside a bulb. In the present paper some preliminary results obtained by this method are given. The spectral lines can be obtained with relatively short exposures by taking as source a compound of the element to be investigated, functioning as a secondary radiator, and exposing it to the rays from a bulb with a Pt or W antikathode which has a current of from 4 to 5 milliamps. passing through it. The secondary spectra photographed by this method compare favourably with those obtained by Moseley who used the primary rays direct from a bulb. The following are some of the results:—

Element.	Chemical State.	Angle of Reflection of the Rays from Rock Salt.	
Arsenic	Sulphide	12·6° (strong)	11·6° (feeble)
Selenium	Metal	11·6	11·6
Bromine	Sodium Bromide	10·7 (strong)	9·5 (feeble)
Rhubidium	Chloride	9·6 (strong)	8·6 (feeble)
Strontium	Chloride	8·9	8·1
Cadmium	Metal	5·4	8·1
Iodine	Zinc Iodide	4·5	8·1
Tellurium	Telluric Acid	4·7	8·1
Mercury	Zinc Amalgam	12·9 (strong)	10·7
Lead	Metal	12·05	10·0
Bismuth	Metal	11·45	9·4
Thorium	Oxide	9·7	8·0
Uranium	Black Oxide	9·5	7·7

E. A. O.

1839. *Anomalous Zeeman-effect in Satellites of Violet Mercury Line ($\lambda 4359$).* H. Nagaoka and T. Takamine. (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 881-887, June, 1914.)—In previous papers [Abstracts Nos. 1958 (1918) and 887 (1914)] on the Zeeman-effect of the satellites of the green and violet mercury lines ($\lambda 5461$ and $\lambda 4047$) it was shown that the changes in wave-length of the satellites produced by the magnetic field are generally different from those observed with the principal lines, both as regards the displacement and the distribution of intensity among the different components. The effect up to strong fields is in most cases anomalous, although in fields of a few thousand gauss, some regularity usually observed in simple lines may still be traced.

The present paper describes a continuation of the experiments to the satellites of the violet line $\lambda 4359$. A satellite of this line in weak fields has been investigated previously by Gehrcke and v. Baeyer and by Luneland [Abstract No. 878 (1911)]. The study of the satellites of this line is specially interesting, as it is accompanied by more than ten satellites, whose modes of displacement

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in magnetic fields are so various that different cases of anomalies already observed in satellites of the two lines mentioned above are also found included among the diverse types found in the companions of this single violet line. The method of observation was exactly the same as in the previous work. It has generally been assumed that the principal line is simple and has finite breadth ; but by using a very high resolving power it has been found that the line really consists of five lines, three of which are nearly equally intense and form a group. The details of the experiments by which the cluster of lines about the principal line was found will be given later ; the fine structure of the lines $\lambda 5461$ and $\lambda 4047$ will also be dealt with. As noticed with the other two lines, the p -components are simpler than the s -components. The general features are exhibited in two diagrams, and the results are discussed in detail. The results here given, together with the earlier results, afford experimental data for testing the theory of coupling of electrons in explaining the different behaviours of the satellites in a magnetic field. A. W.

1840. *Intensity of Reflection of X-rays by Crystals.* W. H. Bragg. (Phil. Mag. 27. pp. 881-899, May, 1914.)—The author first summarises previous work on the question of the relative intensities of reflection of homogeneous X-rays by a crystal in the different orders and the important conclusions regarding the structure of crystal which may be drawn from the results [Abstracts Nos. 876, 1265 (1914), etc.]. The conditions to be satisfied in obtaining more exact numbers are then discussed, especially with regard to correcting for the small irregularities of the crystal. The method finally arrived at consists practically in measuring the integral of the narrow peak, corresponding to a particular wave-length, in the curve connecting the ionisation effect of the reflected rays and the angle of reflection. Values are given in the case of rock salt and it is shown that the intensities of reflection in the different orders from the various planes in the crystal are comparable with each other. In further experiments the effect of temperature of the rock salt on the angle and intensity of reflection was investigated, and it was found that the glancing angle diminishes with increasing temperature. The results show excellent agreement with the theory of Debye [Abstract No. 1078 (1914)]. Experiments are also described showing that when a plate of diamond is set, with reference to the X-ray beam, at the angle of best reflection, an abnormal absorption is obtained, the variation with angle being similar to an absorption band. The various experiments give opportunity for an accurate estimate of the wave-length of the larger constituent of the rhodium doublet, the value found being $\lambda = 0.614 \times 10^{-8}$ cm. E. M.

1841. *Asymmetric Haloes with X-radiation.* W. F. D. Chambers and I. G. Rankin. (Nature, 98. p. 507, July 16, 1914.)—It is found that a radiograph of a lead disc 2.5 mm. thick, when the disc is raised above the photographic plate, does not appear of an even intensity, but gives well within its shadow a distinct white ring. Experiment shows that the brightness, width, and diameter of this ring vary with the distances of the disc from the plate and antikathode ; it also changes from a complete circle to almost a semicircle, the position and dimensions of the absent arc depending upon the orientation of the bulb. The ring is found to be complete when the X-rays are in the plane of the kathode rays and the normal to the antikathode, and from 10° to 15° within the angle of true reflection. Diverging from this direction the circle becomes increasingly incomplete. Apertures, cubes, cylinders, solid and hollow spheres, etc., of various materials give analogous results, the form

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of the white area depending upon the shape of the object. The authors point out that the results seem to indicate that the X-radiation has been differentiated into two main types, one of which may consist of disparate doublets (magnetic); the polarity being distributed radially round a position which coincides with that of max. intensity. This phenomena bears a close analogy to that of unilateral conductivity in crystals.

(Ibid. 98. p. 611, Aug. 18, 1914.) The authors confirm the results already mentioned above. With a V-shaped aperture, the apex resting on the plate, the bands on one side are sharply defined and twice bent; on the other side, there are several bands but they are diffuse and fainter. The diametric asymmetry excludes polarisation, and since it increases directly with the distance from the axis through the "optimum" (i.e. 15° from the direction at which light would be reflected) the rays must have some determination from the plane of the antikathode. In other words, they must be polarised in planes at successive angles to the direction of propagation. The continuance of the bands within the shadow beyond the range of light diffraction, and their varying asymmetry show that X-radiation is something more than light of very short wave-length, or otherwise light itself must possess unequal polarity in its structure.

E. A. O.

1842. *Radiation accompanying the Oxidation of Phosphorus.* A. Blanc. (Comptes Rendus, 158. pp. 1492-1498, May 25, 1914.)—The author briefly describes the experimental arrangement adopted for investigating the effect accompanying the oxidation of phosphorus. It is found when phosphorus oxidises, that a very soft radiation is emitted; this radiation is not corpuscular, but is of the nature of γ -rays. The radiation is readily absorbed in air and is entirely absorbed in a sheet of aluminium 1/50 mm. thick. The oxidation of phosphorus furnishes the first example known of a chemical reaction producing phenomena which are similar, at least in a certain measure, to radio-active phenomena.

E. A. O.

1843. *Transmission of Hard X-rays.* J. Laub. (Phys. Zeitschr. 15. pp. 140-141, Feb. 1, 1914.)—Thick plates of charcoal or sulphur, when traversed by X-rays, emit a very homogeneous hard secondary X-radiation. The author describes a number of experiments made with such plates. Charcoal plates 8 cm. thick, exposed for 100 minutes, show on the photographic plate a distinct succession of haloes due to interference. This effect becomes even more striking when plates 9 cm. thick are used, with very hard primary rays.

E. E. F.

1844. *Ionisation in a Closed Vessel.* E. v. Schweidler. (Phys. Zeitschr. 15. pp. 685-688, July 15, 1914.)—The ionisation in a spherical enclosure resulting from the α -, β -, and γ -radiation from the walls of the enclosure is calculated approximately. The experimental determination as to whether radio-active impurities in the material composing the vessel walls or the specific radio-activity of the material is the origin of the ionisation inside the vessel seems, from the quantitative results obtained, quite possible. [See also Abstracts Nos. 1671 and 1672 (1918).]

A. W.

HEAT.

1845. Dilatation of Ferro-Nickels over a Large Interval of Temperature. P. Chevenard. (Comptes Rendus, 159. pp. 175-178, July 18, 1914.)—The dilatation of pure iron-nickel alloys has been compared with a silica tube as a standard over the temperature interval -195° to $+750^{\circ}$ C. Between the range of composition represented by pure Fe and the compound Fe_2Ni , the alloys were immersed in liquid hydrogen in order to ensure their being in the cold stable state before being examined for changes in dimensions on consecutive heatings and coolings. In this series the results show that the compound Fe_2Ni is the limit of the reversible alloys. Between Fe_2Ni and FeNi , the alloys have abnormal, quasi-reversible properties. Alloys approaching Fe_2Ni , show two inflections in the temperature-coefficient of expansion curve. As they approach the compound FeNi , the first inflection disappears and the second one begins to diminish in intensity. The concentration-coefficient of expansion curves have been plotted for various temperatures and constitute a proof of the existence of the compound Fe_2Ni .

F. C. A. H. L.

1846. Heat Capacity of Metals at Low Temperatures. E. H. Griffiths and E. Griffiths. (Roy. Soc., Phil. Trans. 214. pp. 819-857, Oct. 1, 1914. Roy. Soc., Proc. Ser. A. 90. pp. 557-560, Aug. 1, 1914. Abstract.)—Determinations of the specific heats of Al, Cu, Zn, Ag, Cd, Pb, Fe, and Na have been made at various points between room temperature and -165° C. A new method of maintaining the enclosure at the desired temperature is used in which the cooling is obtained by a direct application of the Joule-Thomson effect in air. Making use of the results obtained by Nernst at very low temperatures [Abstract No. 447 (1918)], the authors have constructed tables of atomic heats extending from 28° to 890° C. abs. The calculated values of the atomic heats at constant volume are also included for the purpose of comparing the results with those obtained from various theoretical formulæ. In the second part of the paper these formulæ are discussed, and it is shown that none of them are capable of representing the experimental results over the entire range of temperature. Debye's formula gives the nearest approximation to the experimental results over the lowest portion of the range, but systematic divergences occur at higher temperatures. This may be due either to the assumptions made by Debye being valid at very low temperatures only, or to the fact that additional heat energy to that involved in the three degrees of freedom ascribed to the atom must be taken into account.

F. J. H.

1847. Formation of Dew and Hoar-frost. A. Lo Surdo. (Accad. Lincei, Atti, 28. pp. 950-958, June 21, 1914.)—Calculates the time of formation of a deposit of dew and of hoar-frost on the basis of the radiation laws, and describes an experiment with a Dewar flask and metallic mirror to imitate natural conditions. The agreement is only qualitative.

E. E. F.

1848. Well-known Experiment in Regelation. S. Suzuki. (Sci. Reports, Tôhoku Univ., Sendai, 1. No. 4. pp. 219-227, 1912.)—The explanation given

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by Lorentz in his "Lehrbuch der Physik" of the passage of a weighted wire through an ice block is used as the basis of a mathematical investigation into the dependence of the rate of fall of the wire upon its dimensions and conductivity, and the weight attached. The results compare favourably with those obtained experimentally under various conditions. F. J. H.

1849. *New Method for determining the Specific Heats of Liquids.* E. J. Hartung. (Chem. News, 110. pp. 126-127, Sept. 11, 1914. Paper read before the British Assoc., Australia, 1914.)—This method, which is a modification of the method of mixtures, consists in measuring the lowering in temperature of a known amount of the particular liquid on the introduction of a definite weight of dry ice contained in a thin glass bulb. The calorimeter is a thin glass vessel of about 100 c.cm. capacity, and is supported inside a silvered Dewar tube, the mouth of which is closed air-tight by a rubber stopper. Through the stopper pass a Beckmann thermometer and a thin glass stirring rod, the lower end of which is shaped to receive the ice-bulb. A third hole, lined with glass and closed with a well-fitting glass stopper, passes through the rubber stopper and serves for the introduction of the ice-bulb, this being cylindrical and containing a definite weight of distilled water, and as much silver gauze as possible, so as to ensure rapid heat conduction and to make the bulb heavy enough to sink in dense liquids. The bulb is suspended by a fine Pt-wire. The liquid to be tested is introduced into the calorimeter by means of a standardisation pipette, and the apparatus is closed until constant temperature is attained. The ice-bulb has meanwhile been frozen in a mercury bath supported in an ordinary freezing-point apparatus. When the temperature of the mercury is constant at from -8° to -4° , the bulb is removed by its suspension and rapidly lowered into the bottom part of the stirring rod in the calorimeter. The liquid is then stirred by hand until constant temperature is again attained, this usually requiring about 8 mins. Radiation corrections are applied, and the specific heat of the liquid calculated, the heat capacity of the ice-bulb being accurately known. The measurements should be made in a room at constant temperature.

The advantages of the method are simplicity, rapidity, and accuracy. With water at 25° , results agreeing to within 0.4 % were obtained. When ether was used, it was necessary to coat the rubber stopper with tin-foil to protect it. The results with ether at 25° —at which temperature ether has a vapour pressure of 545 mm.—agreed to within 1.4 %. The values found for several mixtures of sulphuric acid and water showed an average divergence of less than 1 % from the classical results of Thomsen. The apparatus is not suitable for use with a viscous liquid, such as glycerine, owing to the inefficiency of the stirring. The method could probably be extended in scope by employing a liquid other than water in the bulb.

T. H. P.

1850. *The Freezing-point of Benzene as a Fixed Point in Thermometry.* T. W. Richards and J. W. Shipley. (Amer. Chem. Soc., Journ. 86. pp. 1825-1832, Sept., 1914. Chem. News, 110. pp. 187-189, Oct. 16, 1914.)—One of the authors has already determined the transition temperature of a number of hydrated crystalline salts [see Abstract No. 1178 (1911)] and has shown that these afford one of the most convenient and exact means of fixing points on the thermometric scale between 0° and 100° C. Freezing-points, similarly, can be used for the same purpose on account of the comparatively small

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influence of pressure on the freezing-point, but the requisite purification of the liquids is frequently a matter of the greatest difficulty. In the case of benzene, however, the conditions are fairly favourable, as benzene can be obtained sufficiently pure without too great difficulty. The authors have now determined the freezing-point of carefully purified benzene (the value remaining unchanged after repeated crystallisation of the benzene) and find it to be $5.488 \pm 0.002^\circ$ on the international hydrogen scale. This fixed temperature may be advantageously used in connection with the ice-point of water for calibrating Beckmann thermometers. Especial attention must be paid to the temperature of the exposed column in correcting this interval for use at other temperatures.

A. F.

1851. High-temperature Measurements based on Radiation. C. E. Mendenhall and W. E. Forsythe. (Phys. Rev. 4. Ser. 2, pp. 62-70, July, 1914.)—An attempt to apply Stefan and Boltzmann's fourth-power law of radiation to the measurement of the highest temperatures attainable. The authors succeed in extending the high-temperature scale without extrapolation to 2820°C. , and show that the optional scale based on Wien's displacement law is in close agreement with the total-radiation scale. The latter was compared with the Day and Sosman gas scale over the range 1068°C. to 1549°C. , and found to agree with it within 0.5° . Three determinations of the melting-point of Pt gave the result 1758°C. on the Stefan-Boltzmann scale.

E. E. F.

1852. Rapid Laboratory Method of measuring the Partial Vapour Pressures of Liquid Mixtures. M. A. Rosanoff, C. W. Bacon, and R. H. White. (Amer. Chem. Soc., Journ. 86. pp. 1808-1825, Sept., 1914.)—The authors describe a method for the determination of the partial vapour pressures of liquid mixtures, depending on the following principle. The mixture is distilled, with careful avoidance of reflux condensation, and the distillate collected in separate small fractions, the composition of which is then determined by a refractometric method. By this means one can determine the composition of the distillate when its weight is, say, 1 gm., 2 gm., 8 gm., etc., and by a small extrapolation backwards to zero weight of distillate one obtains the composition of the first indefinitely small amount of distillate, which gives therefore the composition of the vapour in equilibrium with the original liquid mixture. By this method, which is rapid and requires no special experience on the part of the manipulator, the authors have carried out measurements of the vapour pressure of the following binary mixtures: carbon disulphide—carbon tetrachloride; chloroform—toluene; acetone—toluene; ethyl iodide—ethyl acetate.

A. F.

1853. Measurement of Vapour Pressures by the Dynamic Method. Vapour Pressure of Water at 24.97° . I. H. Derby, F. Daniels, and F. C. Gutsche. (Amer. Chem. Soc., Journ. 86. pp. 798-804, May, 1914.)—A new saturator was devised, consisting of two 8-in. bulbs filled with 4-mm. glass-pearls and kept rotating below the water-level of a thermostat; experiments showed that air drawn through at the rate of 50 litres per hour could be saturated completely with water-vapour. The vapour could then be absorbed completely by phosphoric oxide and weighed. The vapour pressure of water was found to be 28.70 mm. at 24.97° , = 28.75 mm. at 25.00° ; earlier determinations by various workers have given 28.55, 28.76, 28.69, 28.79, 28.76, 28.71, 28.75, the average (omitting Regnault's early value) being 28.74 mm. at 25.00°C. A determination of the vapour pressure of alcohol gave 58.47 mm. at 25° .

T. M. L.

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1854. Firing of Gases by Adiabatic Expansion. I. Photographic Analysis of the Flame. H. B. Dixon, L. Bradshaw, and C. Campbell. (Chem. Soc., Journ. 105. pp. 2027-2085, Aug., 1914.)—In order to study the initiation of the flame produced by the adiabatic compression of gases, experiments were made in glass tubes so arranged that the flame could be analysed by being photographed on a rapidly moving film. In the case of a mixture of oxygen and carbon disulphide, which was chosen first because of its low ignition-point and of the actinic character of its flame, the flame always took an appreciable time to spread through the space occupied by the gas, and in no instance did the flame travel through the tube with a velocity approaching that of detonation; the greatest velocity observed was 100 m. per sec., whereas in the same mixture the explosion-wave travels at a rate of nearly 1800 m. per sec. The minimum volume observed when a gaseous mixture is fired by adiabatic compression is found to be no criterion of its ignition-point. Not all explosive mixtures of gases "detonate" when they are fired by adiabatic compression. In the cases examined the flame, after its appearance, takes an appreciable time to spread through the mixture, and meanwhile the piston may continue to advance if there is nothing to check it but the explosion itself. The real ignition-point is, however, not necessarily synchronous with the appearance of the flame, being the temperature at which a mass of the gas self-heats itself by combination until it bursts into flame. If the piston move during the actual spread of the flame it may naturally move during the "pre-flame" period. Experiment shows that not only is this period not negligible but that it may be much longer than the flame-spreading period. In order to determine the ignition-point by the compression it is therefore necessary to stop the motion of the piston artificially at the beginning of the pre-flame period. [Compare next Abstract.] T. H. P.

1855. Firing of Gases by Adiabatic Compression. II. Ignition-points of Mixtures containing Electrolytic Gas. H. B. Dixon and J. M. Crofts. (Chem. Soc., Journ. 105. pp. 2086-2058, Aug., 1914.)—The authors have devised an apparatus which satisfies moderately well the conditions necessary for the determination of the ignition-points of gases by adiabatic compression. This apparatus and its principal sources of error are described in detail. In the case of electrolytic gas ($2H_2 + O_2$), no alteration occurs in the final ignition-point when the initial temperature of the mixture is varied, although in one case, when the initial temperature was 100° , the pressure in the cylinder at the moment of ignition was only 14.5 instead of 85 atmos., the pressure usually reached at room temperatures. Increase of the initial pressure of electrolytic gas to 2 atmos. is without influence on the calculated ignition-point, but its diminution to 0.5 atmo. is accompanied by appreciable rise of this temperature. The ignition point of electrolytic gas is found to be 526° . The following temperatures are for mixtures of $2H_2 + O_2$ with the indicated proportions of oxygen, hydrogen, or nitrogen:—

O_2 , 511°	H_2 , 544°	N_2 , 587°
$7O_2$, 478	$2H_2$, 561	$2N_2$, 549
$15O_2$, 472	$4H_2$, 602	$4N_2$, 571
$81O_2$, —	$8H_2$, 676	$8N_2$, 615
	$18H_2$, 762	$14N_2$, 712
	xH_2 , $526 + 18x$	xN_2 , $526 + 11x$

These results are compared with those obtained by previous investigators.
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Although the addition to electrolytic gas of equimolecular proportions of hydrogen and nitrogen causes a greater rise in the ignition-point in the former case than in the latter, there are no grounds for assuming that a higher temperature is required to explode a mixture containing an excess of hydrogen than one containing a corresponding excess of nitrogen. It is concluded that the greater conductivity of hydrogen necessitates a greater compression or that the value of γ must be different in the two cases, although equal values of γ have been assumed in the calculations. Experiments with argon as a diluent are being undertaken to ascertain the effect of a gas of known specific heat. For the lowering of the ignition temperature caused by excess of oxygen no satisfactory explanation is advanced, but the increased activity of oxygen at the higher concentrations might be explained if oxygen formed an active polymeride under these conditions or if the concentration of the oxygen brought about ionisation of the hydrogen molecules. T. H. P.

1856. *Limits of Inflammability of Fire-damp.* F. Leprince-Ringuet. (Comptes Rendus, 158. pp. 1798-1799, June 15, 1914.)—By limit of inflammability the author understands the minimum percentage at which the inflammation is regularly propagated downward in a tube from the top to the bottom; he finds that the direction is important, the relative limits being: downward 5.76, horizontally 5.56, upward 5.20. Most of the experiments were made in 1910 already with gas from Taffanel's station at Liévin or with gas from the Lens colliery. In determining the composition of the gas it is necessary to remember that the gas collected in the mines is saturated with water-vapour, and that its composition therefore changes with the temperature. This is also to be considered when the analysis is made by the Lebreton apparatus, where the temperature, the percentage of water-vapour, and the solubility of the gases in the water with which they are shaken are to be determined. The author gives a formula for the limit which, he finds, is hardly influenced by the atmospheric pressure (753-797 mm.), but varies with the diam. of the tube, or rather with the diam. of the orifice. H. B.

1857. *Photographic Analysis of Explosions in the Magnetic Field.* H. B. Dixon, C. Campbell, and W. E. Slater. (Roy. Soc., Proc. Ser. A. 90. pp. 506-511, Aug. 1, 1914.)—At the suggestion of J. J. Thomson, the authors have repeated Dixon's experiments on the photography of the explosion-wave under such conditions as to determine whether the form of the wave could be modified by a magnetic field. Thomson had previously called attention to the fact that combustion is concerned not only with atoms and molecules, but also with electrons moving with very high velocities. In the "surface combustions" studied by Bone it appeared probable that the streams of electrons known to be emitted by incandescent surfaces promoted combustion by electrifying the contiguous layers of gas, and the great rapidity of combustion in the explosion-wave might be due to the molecules at the moment of combustion sending out electrons with very high velocities. These may precede the explosion-wave and prepare the way for it by ionising the gas. Now the motion of the ions can be stopped at once by means of a transverse magnetic field (in which they curl up and are caused to revolve in small circles), so that several attempts were made to detect the effect of a magnetic field on the propagation of an explosion-wave. A very complete description is given of the powerful magnets used, including two designed by Rutherford for the purpose of deflecting electrons of high velocity. The

experimental details are very fully described, while sixteen photographs of explosion-waves through different gaseous mixtures are included; these latter were cyanogen and oxygen with different proportions of nitrogen, hydrogen, and oxygen, acetylene and oxygen, carbon disulphide and oxygen, and carbon monoxide with oxygen. In no case did the powerful magnetic field employed produce any visible effect, and since the mechanism of a compression-wave (liberating the chemical energy as it goes along) accounts in a reasonable way for the phenomena of gas explosions, the authors see no convincing evidence that the velocity of the explosion-wave is due to the ionising action of electrons.

H. H. HO.

1858. *Molecular Rotation-energy and the Quantum Theory.* E[va] v. Bahr. (Phil. Mag. 28. pp. 71-88, July, 1914.)—Nernst has pointed out [Abstract No. 900 (1911)] that, in dealing with molecular rotation, we must probably introduce the quantum hypothesis, since the rotation of a molecule—with charged atoms—causes radiation, and that, even with infinitely thick gas layers, we do not find any emission of the shorter waves. The authoress here summarises and discusses the bearing on this question of the most important results of recent investigations of ultra-red absorption by gases. The result strongly supports the assumption of discontinuity in the distribution of rotation frequencies. The cause of the effect of pressure on the absorption, which the authoress has done much to elucidate experimentally [Abstract No. 1946 (1913)], still remains unexplained.

G. W. DE T.

1859. *Relation of Liquid Cohesion to Dielectric Capacity and Permeability.* W. C. McC. Lewis. (Phil. Mag. 28. pp. 104-116, July, 1914.)—The work of Perrin, Millikan, and Svedberg leads to the conclusion that the intervals between molecules in liquids are of the same order as the molecular diameters, a closeness of packing leading to the expectation of large values for the internal pressure or cohesion. E. Obach has noted [Phil. Mag. 81. Ser. 5. p. 113, 1891] an approximate proportionality between the latent heat of vaporisation of a liquid and its dielectric constant. Dupré suggested, long ago, that the latent heat of vaporisation of unit volume of a liquid is a measure of the internal pressure, and though certainly not exactly correct, large latent heat accompanies large cohesion. There should therefore be a rough proportionality between dielectric capacity and cohesion, as maintained by Walden [Abstract No. 862 (1910)]. Calculation from Young's data [Abstract No. 1785 (1910)] of the *minimal* values of the internal pressures of a large number of liquids at 0° C. confirm the Obach-Walden relation, which is here shown to follow from the assumption that the molecular attraction is electromagnetic, not electrostatic, in nature, with the further consequence that large internal pressure corresponds to small permeability. Pascal's relation, viz., that the product of magnetic susceptibility into specific volume is constant for a given substance, is shown to involve constant orbital velocity of the electrons. Bohr's assumption of constant angular momentum in conjunction with this would lead to the conclusion that the vibration-frequency of the visible and ultra-violet absorption bands should be the same for both liquid and vapour, a conclusion which is only approximately in accord with experiment. The effect of temperature in partially destroying orientation of the molecules appears to alter the inverse fourth-power law to the inverse cube, as expressed in Dieterici's equation $(p + a/v^{5/3})(v - b) = RT$. [Abstract No. 80 (1900).]

G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1860. Ponderomotive Force on a Dielectric carrying a Displacement Current in a Magnetic Field. R. H. Goddard. (Phys. Rev. 4. Ser. 2. pp. 99-120, Aug., 1914.)—According to Lorentz's theory of a dielectric, a ponderomotive force must act upon it when carrying a displacement current in a magnetic field, analogous to the force which is known to act upon a conductor when carrying a conduction current in a magnetic field. An experiment performed by Whitehead in 1902 gave a negative result, and this was shown to be in accordance with theory (Lorentz, Gans, Koláček). The author now develops a more general theory, which includes Whitehead's experiment as a special case, and further suggests an experiment by which a positive result should be obtained. A preliminary experiment with a piece of ebonite has given a ponderomotive form of the required order of magnitude.

E. E. F.

1861. Effect of the Magneton in Scattering of α -Rays. W. M. Hicks. (Roy. Soc., Proc. Ser. A. 90. pp. 856-864, July 1, 1914.)—Treats mathematically the simple case of charged particles moving in the equatorial plane of a fixed magnetic doublet without taking account of a central nuclear charge. The orbit described depends upon the direction of approach. If this is originally along the axis of x towards the doublet at the origin, the path is an equilateral hyperbola with the axes of x and y as asymptotes. Particles approaching towards one side of the magneton's centre are less sharply deflected, those approaching towards the other side of the centre may be turned back with or without one or more loops. These paths are plotted in two diagrams and their equations and properties fully calculated.

E. H. B.

1862. Electron Theory of Thermomagnetic Effect. H. Zahn. (Phys. Zeitschr. 15. pp. 668-665, July 1, 1914.)—Discusses mathematically the simplifying assumptions and, with their help, obtains the coefficient of the thermomagnetic effect from the equations of the theory of Gans. [See Abstract No. 556 (1914).]

E. H. B.

1863. Electrification at Liquid-Gas Surfaces. H. A. McTaggart. (Phil. Mag. 28. pp. 867-878, Sept., 1914.)—In continuation of his previous work [see Abstract No. 958 (1914)], the author has examined the velocities of bubbles of air in aqueous solutions of a number of alcohols, fatty acids, etc., and in a few pure alcohols. The results show that the addition of an alcohol to water reduces the electrification at the liquid-gas surface, the effectiveness of any alcohol in this respect corresponding with its effectiveness in reducing the surface tension of water. In the case of air-bubbles in pure alcohols, there appears to be no cataphoresis. The fatty acids diminish the charge at the gas-liquid surface in aqueous solutions, but no reversal was observed with the concentrations used. A marked variation of velocity with size of air-bubbles in cataphoresis experiments is produced by the presence in the aqueous solution of substances having

a pronounced effect on the surface tension. Evidence is adduced to show that the electrification in water-fall experiments is not due to the difference of potential observed in the cataphoresis experiments. T. H. P.

1864. *On Some Sources of Disturbance of the Normal Atmospheric Potential Gradient.* W. A. D. Rudge. (Roy. Soc., Proc. Ser. A. 90. pp. 571-582, Sept. 7, 1914.)—The author has in the past made many observations on the effect of dust clouds on the potential gradient in Africa [see Abstracts Nos. 1182 (1918) and 886 (1914)]. More recently he has conducted experiments near to roads in Great Britain, and has found that the raising of dust by a passing vehicle has a pronounced, though transitory, effect upon the potential gradient. In the case of freshly-repaired sandy roads this effect may be in the direction of a reduction of the normal positive gradient, but with all old roads the disturbance takes the form of an increase of the positive gradient. This is ascribed to the presence of organic matter, which enters largely into the dust of a road that has been in use for any length of time. Manufacturing operations which produce much dust also have a very pronounced effect on the potential gradient. One hundred paces from a large Portland cement works the gradient was found to be + 880 volts/m., and this was not reduced to the normal value at the time in a free exposure, 70 volts/m. within 1000 paces of the works. Steam from passing trains has a very similar effect, the passage of each train being shown by a large rise in the gradient in the neighbourhood. It is thus demonstrated that purely local effects may have a large influence on the potential gradient. J. S. Di.

1865. *New Atmospheric-electric Instruments and Methods.* W. F. G. Swann. (Terrestrial Magnetism, 19. pp. 171-185, Sept., 1914.)—A serious fault in the well-known apparatus designed by Ebert for determining the number of ions per c.cm. of air is the length of the time over which the experiment must extend in order that a measurable fall in the potential of the inner charged rod may be produced. This potential is normally about 200 volts and the electroscope by which it is measured is not adapted to measure such a small fall of potential as would occur if the air current were allowed to flow through the apparatus for a few minutes only. The modification adopted by the author in order to overcome this difficulty consists in charging the outer cylinder of the apparatus to a high potential while the central rod is initially at zero potential. Small changes in the potential of this inner rod can then easily be measured and the time necessary for an experiment is materially reduced. Certain difficulties are introduced by the change of method, and modifications are included to overcome these. In the usual method of measuring the radio-active content of the atmosphere a wire charged to about 2000 volts below the earth's potential is freely exposed for a definite time in the air during which time it becomes more or less radio-active. The author points out that in the reduction of the observations the charge upon the wire during its exposure is of importance, and this charge depends amongst other things upon the potential gradient existing at the time and is thus difficult to determine accurately. It is proposed to maintain the potential of the wire at a constant value below that which the space occupied by the wire would have in the absence of the latter, instead of below the earth's potential; by this means the source of error introduced by variations in the potential gradient is overcome. A method by which this end may be achieved is set out. The last piece of apparatus described forms a novel method of measuring the potential gradient. If the position of an
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insulated body be moved in an electric field, its potential will change and the amount of this change will be proportional to the potential gradient in the field. The instrument described is based on this principle and is particularly suitable for use at sea, where the ordinary methods of measurement cannot be regarded as very satisfactory.

J. S. DI.

DISCHARGE AND OSCILLATIONS.

1866. Volume Charge due to Positive Ions. W. Schottky. (Phys. Zeitschr. 15. pp. 656-657, July 1, 1914.)—According to C. D. Child [Abstract No. 1208 (1911)] it takes about 10 volts to produce a current of 1 micro-amp. consisting of positive ions issuing from an electrode in a high vacuum. For electrons proceeding from thin wires to coaxial cylinders a law of the form $I = \frac{2}{9} \times (2\gamma)^{1/2} \Phi^{3/2} / R$ has been put forward and verified. The author shows that such a law is also approximately fulfilled in the case of positive ions proceeding from a carbon filament.

E. E. F.

1867. Origin of the Electron Emission from Glowing Solids. F. Horton. (Roy. Soc., Phil. Trans. 214. pp. 277-294, Sept. 24, 1914.)—Recent researches on the negative ionisation from glowing solids have thrown doubt on the accuracy of the view of the origin of this ionisation which has been developed by O. W. Richardson. This view is based on the electron theory of metallic conduction, and supposes that an electron entering the surface layer with a normal velocity component greater than a certain amount is able to escape into the surrounding space and to take part in carrying the thermionic current. On this view, as Richardson has shown, the electron emission increases rapidly with the temperature, the connection between these quantities being given by an exponential formula, $i = A\theta^{1/2} e^{-\theta/2\theta_0}$, where i is the thermionic current, θ the absolute temperature, and A and θ_0 are constants. That this formula represents, with fair accuracy, the observed results in the case of platinum and of certain other substances for temperatures up to 1500°C. has been shown by the experiments of Richardson, by H. A. Wilson, by the author, and by other experimenters. Experiments made at higher temperatures, however, have generally shown that the current increases less rapidly with the temperature than is required by this formula. H. A. Wilson has further shown that the current measured at any temperature depends very largely upon the nature of the residual gas present in the apparatus. This has led to the view that the ionisation is entirely due to chemical action between these gases and the heated solid—a view which is also in agreement with the exponential relation between the current and the temperature, for such chemical changes as might occur would probably increase with the temperature in this manner. This chemical action theory has received considerable support from the experiments of Haber and Just, and of Fredenhagen on the alkali metals, and of Pring and Parker on carbon. Richardson has recently described some experiments with a tungsten filament heated to a high temperature in a good vacuum, and has considered the following different hypotheses as to the possible mode of origin of the electronic emission: (1) The emission is due to the evolution of gas by the filament. (2) The emission is caused by chemical action or by some other cause depending on impacts between gas molecules and the filament. (3) The emission is the result of some process involving consumption of tungsten. Experiments were devised for the purpose of testing each of these theories, and in each case it was found that the observed emission was very

much greater than could be accounted for by the hypotheses. The view that the electron emission from glowing lime occurs as a result of the recombination of calcium and oxygen which have been liberated electrolytically has been put forward by Fredenhagen. In 1905 the author investigated the electric conductivity of lime at high temperatures and came to the conclusion that the conductivity is mainly carried on by electrons set free in the interior of the oxide, but that some electrolysis also occurs. Thus there is the necessary condition for the hypotheses as to the origin of the activity of a lime kathode put forward by Fredenhagen.

The experiments described in the present paper were performed to test the "chemical action" theory of the working of an oxide kathode. Fredenhagen experimented with a mixture of lime and magnesia, which is a better conductor than lime alone. The experiments here described were made with Nernst filaments which consist of a mixture of oxides having a much greater conductivity than the mixture used by Fredenhagen. It has been found by Owen that these filaments give a large electron emission at high temperatures. The following points have been investigated :—(1) Does the electron emission from a Nernst filament depend upon whether the heating current is alternating or continuous? We should expect that if the conduction through these filaments is electrolytic, the recombination of the constituents would be more complete with an alternating current than when a continuous current is employed; so that, if the electron emission depends upon this recombination, the thermionic current at a given temperature should be greater in the former case. (2) Is the emission from a Nernst filament the same when it is heated by conducting an electric current and when it is heated by a metal wire being raised to incandescence by an electric current? In the latter case practically the whole of the heating current is carried by the metal wire, and any electrolysis which occurs is due to the thermionic current; so that recombination must be very much less under these circumstances than when the filament itself conducts the heating current. (3) The emission from a Nernst filament heated in the ordinary manner has been compared with that given by the same material when powdered upon Pt. This experiment is similar to that just mentioned. These experiments show that the oxides of which these are made suffer electrolysis when conducting an electric current, but that the electron emission which occurs at high temperatures is not due either directly or indirectly to this electrolysis, for the magnitude of the emission at a given temperature is the same whether the current through the material is great or small. It is therefore concluded that the emission from lime in a Wehnelt kathode is not due to the recombination of electrolytically separated calcium and oxygen, as has been suggested. Owing to the increasing chemical activity of substances at high temperatures, and to the impossibility of removing all traces of impurities from the discharge tube, it is very difficult to prove conclusively that any known case of electron emission is purely a thermal effect; but, on the other hand, there is no satisfactory evidence that ionisation is ever produced by chemical action alone. It would seem, therefore, that the theory that thermal agitation is by itself sufficient to cause the emission of electrons from matter could only be disproved by reducing the thermionic current from a metal at the highest attainable temperature to zero. The increased ionisation from a glowing kathode which occurs when a chemically active gas is allowed to enter the discharge tube may arise in several ways: (1) It may be directly due to chemical action; (2) it may be indirectly due to chemical action, arising as a consequence of an increase of temperature resulting therefrom, or from

the product of the action having a greater activity than the original substance of the kathode ; (8) it may be due to an alteration of the surface conditions at the kathode in such a manner as to make it easier for the electrons to escape, for instance, by the formation of an electric double layer ; (4) it may be due to ionisation by collisions.

It seems probable that the cause of the increased activity is different in different cases. A. E. G.

1868. *Emission of Ions by Non-radio-active Salts.* D. Pacini. (N. Cimento, 7. Ser. 6. pp. 287-290, May, 1914.)—Studies the ions emitted by ammonium sulphate and nitrate, potassium bromide, quinine sulphate, and a few other substances [see Abstracts Nos. 782 (1905), 1062 (1907)], and shows that the ions are probably due to some electrochemical action of water-vapour upon these salts. E. E. F.

1869. *Conductivity of Salt Vapours.* S. J. Kalandyk. (Roy. Soc., Proc. Ser. A. 90. pp. 634-647, Sept. 7, 1914.)—It has been shown by Beattie, Garrett [Abstract No. 1881 (1907)], and Garrett and Willows, that when certain salts are heated up to 300-400° C. the discharge of positive and negative electricity can be observed. This phenomenon is noticed more particularly in the case of the halogen salts of cadmium, zinc, and ammonium. The researches of Schmidt and Sheard [Abstract No. 1028 (1918)] have shown that the discharge is due to two factors : (1) emission of the charges from the surface of the heated salt, and (2) to the conductivity of the salt vapours themselves. The thermionic effect of the above-mentioned salts was studied in detail by O. W. Richardson [Abstract No. 182 (1914)] and his pupils, while some investigations of the electrical properties of the salt vapours was made by Schmidt in the papers referred to above. The object of the present research was to investigate the influence of the temperature, water-vapour, time, etc., on the current passing in the salt vapours. The special form of apparatus used is described in detail. The experiments described show that the conductivity of the salt vapours is due to the processes occurring in the vapours themselves. The vapours of carefully dried salts conduct the electric current. Therefore the conductivity cannot be ascribed to the chemical action of water-vapour on the salt vapours. However, the presence of water-vapour increases the current passing in salt vapours. When cadmium is very carefully dried, it is possible to observe a current which is practically independent of time. The connection between the current i and the temperature θ may be expressed with considerable accuracy by the formula $i = ae^{-b/\theta}$, where a and b are constants. The ionising potential calculated from the energy of dissociation is considerably less than that for the ordinary gases. The dissociation of vapours is, however, not always accompanied by ionisation. A. E. G.

1870. *Theory of Ionomagnetic Rotations.* A. Righi. (Accad. Lincei, Atti, 28. pp. 897-908, June 21, 1914. N. Cimento, 7. Ser. 6. pp. 291-308, May, 1914.)—Gives a fuller theory of rotations produced by ions in a magnetic field [Abstract No. 181 (1914)]. In order that this theory may be more fully verified, it will be necessary to ionise the gas in some other way than by sparking. E. E. F.

1871. *Photoelectric Photometry.* J. Elster and H. Geitel. (Phys. Zeitschr. 15. pp. 610-611, June 15, 1914.)—The rule according to which the photoelectric current of a potassium cell is proportional to the strength VOL. XVII.—A.—1914.

of illumination [Abstract No. 128 (1914)] is not strictly fulfilled in the case of very intense light, such as direct summer sunlight. With an accelerating voltage of more than 20 the current may rise from 8 microamps. to about 1 milliamp. This is due to shock ionisation in the low-pressure argon which fills the cell, as may be seen by the luminous discharge. The remedy is either to employ a very high vacuum or to stop down the aperture in a known ratio until the shock effect becomes negligible. In any case, the current should always be of an order not exceeding 1 microamp. E. E. F.

1872. *Secondary Radiation from Canal Rays on an Insulator.* J. Koenigsberger and A. Gallus. (Deutsch. Phys. Gesell., Verh. 16. 4. pp. 190-194, Feb. 28, 1914.)—The problem was whether during secondary radiation (the liberation of electrons on the impact of canal rays) there were any effects of affinity. The secondary radiation from metals was compared with that from a good insulator at an incidence of from 70° to 80° . The insulator was found to give far less secondary radiation than the metal. Positive canal rays gave about one-third the radiation set up by neutral canal rays. The diffuse reflection of canal rays is much the same with the insulator as with metals. The secondary radiation from brass corresponds, under the conditions of the experiments, to the liberation of from two to four electrons per atom caught in the incident canal rays. [See also Abstracts Nos. 905 (1912), 1184 (1913).] A. D.

1873. *Action of a Wehnelt Kathode.* F. Horton. (Phil. Mag. 28. pp. 244-252, Aug., 1914.)—In a previous paper the author gave reasons for supposing that the activity of a Wehnelt kathode is not due to an escape of electrons from the molecules of lime simply as the result of an increase in their thermal energy. The presence of the electronegative oxygen atom in the lime molecule would hinder the escape of electrons so that we should expect to get a greater emission from pure calcium on Pt than from lime; the reverse, however, was found to be the case. Experiments have now been made to compare the activity of lime on Pt with that of lime on a Nernst filament. Within the limits of experimental error these are the same, so that the electron emission has its origin in the lime itself, and the lime does not merely serve to help the electrons to escape from the metal. Fredenhagen has suggested that the electron emission arises from the recombination of Ca and O liberated electrolytically; A. Gehrts [see Abstract No. 125 (1914)] gives a modification of this view to the effect that the separation of Ca and O is caused not by electrolysis but by thermic dissociation. To test these theories experiments were made upon the gas liberated from the lime. These reveal the fact that the amount of oxygen liberated is only a very small fraction of what would be expected if the conductivity of the lime were entirely electrolytic. Further, it was found that the chemical combination of Ca and O does not of itself give rise to any detectable electron emission, so that it appears that the theories of Fredenhagen and Gehrts cannot be accepted as an explanation of the activity of the Wehnelt kathode. F. J. H.

1874. *Disintegration of the Aluminium Kathode.* L. L. Campbell. (Phil. Mag. 28. pp. 847-854, Sept., 1914.)—The aluminium kathode in discharge-tubes has been supposed not to disintegrate to any marked extent, except in the monatomic gases. The author has undertaken a preliminary investigation to find if the aluminium kathode disintegrates in the presence of Cl and of other gases. It was found that it does "splutter" violently in the presence of the halogens, certain metallic vapours and other gases. The disintegration. VOL. XVII.—A.—1914.

tion of the kathode seems to take place best when the pressure in the tube has reached the ordinary X-ray stage, and when the kathode dark-space has reached the walls of the tube next the kathode. The rate of disintegration seems to increase in general with the molecular weight of the discharge gas. It seems probable that under proper conditions the Al kathode will disintegrate in all gases more or less rapidly.

J. J. S.

1876. Potential to Maintain Current between Coaxial Cylinders. J. S. Townsend. (Phil. Mag. 28. pp. 88-90, July, 1914.)—The potential required to start a discharge between a wire and a large coaxial cylinder has a definite value V_0 , and the rise $V-V_0$ required to maintain a given current has been found experimentally. For small currents, $V-V_0$ is proportionate to C , the current per unit length of wire, and the author has given a simple formula connecting them [Abstract No. 1882 (1918)] obtained by assuming the ions to be produced from molecules of the gas by collisions within a short distance of the wire, where the electric force is large. C affects the field of force owing to the charge from ionisation in the gas, chiefly from ions of the same sign as the charge on the wire. The volume distribution so arising tends, during current flow, to diminish the electric force near the surface of the wire. Thus, to maintain the current the p.d. between wire and cylinder must be increased. A relation between V and C is then obtained by assuming the electric force at the surface of the wire to be that corresponding to V_0 and that the velocities of the ions are proportional to the electric force. The latter is not true for negative ions moving in gases at low pressures, but the resulting formula, when compared with experimental results, shows very clearly many properties of the negative ions.

G. W. DE T.

1876. Discharge of Electricity from Points. P. J. Edmunds. (Phil. Mag. 28. pp. 284-244, Aug., 1914.)—The author has previously shown in conjunction with J. S. Townsend [Abstract No. 1595 (1914)] that if V be the p.d. necessary to cause a discharge to pass between two conductors through a gas at pressure p , then if the linear dimensions are reduced in the ratio $1/k$, the same potential will be required for a gas pressure of kp . This relation was found to be valid for concentric cylindrical electrodes. Measurements of a similar character have now been made for discharges from hemispherically pointed wires to a plane, with identical results. A considerable "lag" between the application of the potential and the passage of the discharge was experienced. In the final measurements this was overcome by the presence of a weak ionising agent which was found not to cause any change in the value of the sparking potential. Dealing with the problem theoretically the author has succeeded in developing an approximate formula connecting the potential required with the dimensions and gas pressure. For the smaller wires the calculated values lie between those found experimentally for positive and negative charges; the agreement for the larger points although of the right order is not so good. The connection between the electric intensity at the vertex of the point and the radius is found to be $f\sqrt{a}=60$, where f is in electrostatic units and a in cm. This is in good agreement with $f\sqrt{a}=56.9$ found empirically for liquid points by Zeleny [Abstract No. 1108 (1914)].

F. J. H.

1877. Distinction between the Spark Discharge and the Arc. A. Occhialini. (N. Cimento, 7. Ser. 6. pp. 865-878, June, 1914.)—The first part of the paper is concerned with showing that the spark is the initial stage of the

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discharge, the final being an arc. The arc takes place when the electrode can rise sufficiently in temperature to emit a copious supply of ions. By examining the discharge by the rotating mirror method, using a solution as one electrode, the arc stage is suppressed, the "pilot" only being present. If the discharges are examined spectroscopically, the pilot gives a line spectrum. But on using metallic electrodes the arc spectrum has bands. The two discharges become similar in form if the self-inductance of the circuit is reduced to a minimum.

In the second part a method of producing oscillations in an arc, without the use of capacity or inductance, is described. The two arc electrodes A and B are maintained respectively at 0 and 110 volts, while a third electrode C at right angles to the other two is maintained at -110 volts. The arc takes place between B and C, but a magnetic field parallel to AB drives it on to AB. Oscillations in both circuits are found to occur, and these are examined by means of the oscillograph. S. G. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1878. *Wave-length-sensibility Curves for Selenium.* F. C. Brown and L. P. Sieg. (Phys. Rev. 4. Ser. 2. pp. 48-61, July, 1914.)—An analysis of sensibility curves in terms of wave-length of incident light requires at least two separate light actions in the selenium. Knowing that the structure of light-sensitive Se is complex, and knowing what we do about the nature of this complexity, we should now perhaps be in a position to apply the electron theory to an explanation of the phenomenon. The double refraction shown by some Se crystals is of importance, for crystals which are directive towards light should also be directive in their electrical properties. Light probably does not act on the Se atoms as units. Rather a large unit, say a crystal unit, is the seat of the disturbance by light action. Crystal boundaries must be recognised when dealing with the flow of electrons in Se, and possibly also in other elements. E. E. F.

1879. *Properties of Selenium.* F. C. Brown. (Phys. Rev. 4. Ser. 2. pp. 85-98, Aug., 1914.)—The author produced a great variety of Se crystals, some of them very large. Nearly all showed a marked selective transparency, a large amount of light penetrating to a depth of 0.2 mm. All the forms tested were found to be conducting, the specific conductivity varying from 200 to 10^7 . All but one proved to be doubly refracting, and in every crystal the conductivity increased on illumination. The light acts in the Se itself and not at the contacts. The conductivity may be increased 1000 times by pressure, and the change of conductivity on illumination is always proportional to the conductivity in the dark. The temperature at which the crystals sublime in mass influences the character of the wave-length-sensibility curves. The study of individual Se crystals is free from many of the difficulties presented by Se bridges. E. E. F.

1880. *Influence of Tellurium on the Light-sensitiveness of Selenium.* Abonnenc. (Comptes Rendus, 159. pp. 41-48, July 6, 1914.)—Selenium "bridges" with carbon electrodes were made of purified Se to which from 1 to 7 % of tellurium had been added. The various specimens were exposed to light filtered through colour screens, and the relative conductivities noted. The Te produced in general a reduction of the sensitiveness, but an increased sensitiveness to red light, which was granted with a 1 % addition. E. E. F.

1881. *Evidence for Electron Atmospheres*. F. F. Householder. (Phys. Rev. 4. Ser. 2. p. 47, July, 1914.)—Wood's observation [Abstract No. 885 (1918)] that narrow cuts across a silver film do not materially interfere with its conductivity was taken as evidence for an atmosphere of electrons extending about one sodium wave-length (0.6μ) from the silver atoms. The author has repeated this experiment with much narrower strips and examined them with a microscope magnifying 1500 diameters. Metallic bridges were found wherever the conductivity was practically unaffected. But when the rulings were clear of bridges, the resistance exceeded 100 megohms. The conclusion is that if the electron atmospheres exist they do not extend farther than 0.15μ . E. E. F.

1882. *Electrical Conduction at High Temperatures*. E. F. Northrup. (Amer. Electrochem. Soc., Trans. 25. pp. 878-890; Discussion, pp. 890-892, 1914.)—The paper is chiefly a *résumé* of the results of measurements by methods which the author has already published [see Abstracts Nos. 491B and 1128A (1914)] of the resistivity at high temperatures of the metals, Na, K, Hg, Cd, Pb, Zn, Sn, Bi, Sb, Cu, Al, Ag, and Au; also of the alloys Na-K and brass. Curves are given which display the following features: A change of state is always accompanied by an almost sudden change in resistivity. For metals which expand on liquefaction the resistivity a little more than doubles. For both Bi and Sb which contract, it diminishes. With the exception of Zn, Cd, and Sb, the increase in resistivity with temperature is very nearly linear when the metals are molten, and may be used to measure with precision a high temperature in a laboratory furnace. With at least six pure metals the resistance coefficient is closely connected with the coefficient of expansion, the ratio of the two coefficients being approximately a constant quantity. This suggests that with increasing temperature the increase in resistivity is closely associated with the increase in the distance between the atoms or molecules. Insulators decrease in resistivity very rapidly with increase of temperature, so much so that at 1600°C ., or over, the insulators have a resistivity of the same order of magnitude measured in ohms as the molten metals have measured in microhms. In the *discussion*, J. W. Richards pointed out a connection between the ratio of resistivities in the molten and solid states, the melting-point, the atomic weight, and the latent heat of fusion. F. J. H.

1883. *Electrical Resistance and Critical Ranges of Pure Iron*. G. K. Burgess and I. N. Kellberg. (Washington Acad. Sci., Journ. 4. pp. 486-440, Sept., 1914.)—The resistance of an iron wire and one of Pt wound on the same support and enclosed *in vacuo* in a quartz tube have been compared every few seconds during both heating and cooling. The results show that the resistance of iron increases with a gradually increasing temperature-coefficient as the temperature rises from 0°C . to above 650°C . As A2 is approached, there is a rapid rise in the resistance-temperature curve, culminating in a cusp at 767° in the temperature-coefficient curve. At A₂ the resistance falls rapidly, but the decrease is recovered within an interval of 25 deg. C. On cooling the reverse phenomena are observed. It appears, therefore, that A₂ is a strictly reversible transformation, and that A₈ is a transformation taking place at a higher temperature on heating than on cooling. These results are in agreement with the thermal results described in Abstract No. 1008 (1914), but whether both A₂ and A₈ are to be regarded as allotropic points will depend on the precise definition of allotropy. The

behaviour at A2 appears to be similar to that of a pure substance at its melting-point, while at A8 there are progressive changes in the electrical and thermal properties which are not reversible. A2 is the temperature associated with the abrupt reversible change of iron from the ferromagnetic to the paramagnetic state, but no crystallographic change has yet been observed at this temperature. The A8 point is, however, certainly associated with a change in the crystallographic state.

F. C. A. H. L.

1884. *Contact Difference of Potential of Distilled Metals.* A. L. Hughes. (Phil. Mag. 28. pp. 887-847, Sept., 1914.)—The contact p.d. between metals was investigated, and particularly its relation to the presence or absence of occluded gases. The result of the experiments showed that the contact potential between metals under ordinary conditions depends to a very great extent upon the gas absorbed in the surface. The contact p.d. between Zn and Bi, both distilled *in vacuo*, and Pt, was measured. Initially there is but little contact difference of potential between the distilled metal and platinum, but the admission of a trace of air into the vacuum causes a great increase in the contact p.d. The change occurs at the surface of the distilled metal which becomes more electropositive. A maximum is reached, after which the contact p.d. decreases to a steady value that is scarcely affected by the presence or absence of air. It is not possible at present to say whether the effect is due to mere absorption of the gas or to something of a more definite chemical nature.

J. J. S.

1885. *Volta-effect.* J. Guyot. (Comptes Rendus, 159. pp. 807-811, July 27, 1914.)—If the apparent difference of potential at the contact of a metal and distilled water is measured and then at the surface of the water extremely slight traces of certain insoluble organic substances be deposited, the apparent p.d. is found to diminish very notably, and may even become inverted. When a very dilute solution of triolein in pure benzene of commerce was added drop by drop on a surface of water, the diminution of the Volta-effect occurred very rapidly at first, even before the free surface of the water was entirely covered by oil molecules. It is almost terminated when the substance deposited forms a monomolecular layer, although then, according to Rayleigh's experiments, the surface tension is still equal to that of pure water. On adding more drops a rapid lowering of the surface tension is produced whilst the diminution of the Volta-effect proceeds more slowly and attains finally a limiting value. The variation of the apparent p.d. precedes the variation of the surface tension, and there does not appear to exist a simple relation between the capillary constant and the difference of potential which occurs at the free surface between air and water covered by a thin layer of organic substance. The greater part of the substances used were placed on the water in a solution in benzene, but experiment indicates that the solvent does not intervene, and that the limiting values of the lowering of the Volta-effect are characteristic of the substances spread over the water, directly or by means of a volatile solvent. Tables are given of the limiting values of the lowering of the Volta-effect at ordinary temperatures with various organic substances employed. That for triolein, for example, is 0.830 volt.

J. J. S.

1886. *Pyro-electricity and the Quanta Theory.* S. Bogusławski. (Phys. Zeitschr. 15. pp. 569-572, June 1, 1914.)—To explain pyro-electricity, it is assumed that the displacement x of a charge from its equilibrium position in a solid corresponds to an amount of work given by $ax^2 + bx^3$. In carrying out

the calculation according to the ordinary statistical mechanics, the result does not agree with experiment at low temperatures. An agreement is, however, obtained by using the quantum theory. The author compares his formula with Ackermann's figures for red tourmaline. The agreement is good, except below 100° abs. and above 500° abs. The outstanding deviations are attributable to the "pseudo"-pyro-electricity indirectly due to heat.

E. E. F.

1887. *Mercury Rectifiers*. W. Jaeger. (Archiv f. Elektrotechnik, 2, pp. 418-480, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The behaviour of mercury rectifiers is theoretically studied for various combinations with resistances, capacities, and inductances. Sine currents are assumed, and the minimum e.m.f. is taken into account. The chief cases dealt with are : mercury valve in series with resistance and inductance ; valve in series with resistance, and in parallel with inductance ; capacity or resistance in parallel with valve. Special attention is devoted to the practically important question of the enlargement or reduction of the zone of transmission. The equations obtained are illustrated by diagrams.

E. E. F.

1888. *Potassium Photoelectric Cells*. H. E. Ives. (Astrophys. Journ. 89, pp. 428-458, June, 1914.)—A detailed investigation is made of the construction and behaviour of potassium photoelectric cells with a view to their use for photometry. Full practical instructions are given for their preparation. The investigation, carried out mainly by means of a quadrant electrometer, shows that the relation between illumination and current is not linear, but is a complicated function of voltage, electrode distance, and pressure, as is the relation between current and voltage. It is concluded that gas-filled photoelectric cells do not possess the qualities more desirable in a physical potentiometer.

E. E. F.

1889. *Testing of Potentiometers*. F. Wenner and E. Weibel. (Washington Acad. Sci., Journ. 4, pp. 469-471, Oct. 4, 1914. Paper read before the Amer. Physical Soc. Electrical World, 64, p. 874, Oct. 31, 1914. Abstract.)—The errors of a potentiometer can be determined by measurements of the resistances of the various sections, but without some systematic method of applying corrections they are not easily allowed for in the use of the potentiometer. In order to reduce the time required for making the measurements and to obtain the data in such form that the corrections can be more easily calculated, a special "ratio-set" equivalent to 211,110 resistance sections of 0.01 ohm each, has been constructed. In use the ratio-set is connected in parallel with the potentiometer to be tested in such a way as to form 2 arms of a bridge, while the potentiometer forms the other 2 arms, the arrangement constituting a Matthiessen and Hockin bridge.

F. E. S.

1890. *Primary Mercurial Resistance Standards*. J. Obata. (Mathematico-Physical Soc., Tōkyō, Proc. 7, pp. 346-354, July, 1914.)—Five new mercury standards of resistance have been constructed at the Electrotechnical Laboratory, Tōkyō. The tubes were calibrated with 2-cm. and 5-cm. mercury threads ; the end planes of the tubes were polished optically flat ; the contained mass of mercury determined by the Reichsanstalt method ; and the resistances were compared by the modified Wheatstone bridge method suggested by the National Physical Laboratory. The tubes used are of Jena 16^{mm} glass, are annealed, but do not appear to have been straightened.

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The calibre factors of the 5 tubes are as follows : 1·000021, 1·000051, 1·000052, 1·000079, and 1·000098. The longest tube is 99·6 cm. and the shortest is 79·8 cm. The mean value of 4 manganin coils at 20° C. in terms of these 5 mercury resistances is 1·00008, int. ohms and the mean value of the same coils in terms of 5 mercury resistances made at the National Physical Laboratory is 1·00007, int. ohms.

F. E. S.

ALTERNATING CURRENTS AND MAGNETISM.

1891. *Preparation of Alloys for Magnetic Research.* J. de Freudenreich. (Archives des Sciences, 88. pp. 86-45, July, 1914.)—The alloys dealt with are those of Fe with Ni and Co. Referring to the fact that ferro-cobalt has a 9 per cent. superiority over iron when saturated, the measure of the saturation intensity of the alloy is taken as a convenient criterion of the success of the operation. The method of measuring the saturation intensity having been described [Abstract No. 995 (1910)], alloys were first produced by the aluminothermic or thermit method of heating. This gave specimens which were only 6·9 per cent. better than the standard iron, a result ascribed to the impurities unavoidably present. The method finally adopted was that of the electric furnace. The metal was melted within a carbon tube raised to about 2000° C. by a current of 2000 amps., and two blocks of 20 kg. were cast of which the second alone was serviceable.

G. E. A.

1892. *Thermal and Magnetic Effects in Iron, Nickel, and Cobalt at High Temperatures.* K. Honda. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 2. pp. 69-94, 1913.)—Employing the Roberts-Austen differential method, a notable thermal effect was observed in iron, nickel, and cobalt during the magnetic transformation, and in all cases the thermal effect (smallest in annealed Co) takes place within a wide temperature interval. In iron and nickel, the initial temperatures of the magnetic change during cooling, and the final temperatures during heating, coincide with the corresponding temperatures of the thermal effect. During cooling, the evolution of heat stops at a much lower temperature than the magnetic change; during heating, the thermal effect also begins at a lower temperature. With a given field, the magnetic change takes place within definite limits of temperature, but the thermal effect is independent of the field. In weak fields the magnetic transformation in iron, steel, and nickel takes place within a small interval of temperature, but increase of the field causes a great increase in the temperature interval. In steel, the course of the intensity-temperature curve is interrupted by the eutectic change, the discontinuity being greater, the greater the amount of the eutectic. In pure iron, the β - γ change takes place at a definite temperature; in steel, the change takes place over a range of temperature. The initial temperature of this change during cooling diminishes with increase of carbon, the lower limit of the change being the temperature at which the eutectic separates out. The thermal effect at the α - β change begins, for all steels, at about the same temperature, and extends to the temperature of eutectic separation. The author expresses his views with regard to the α - β - γ changes [see Abstract No. 1188 (1914)]. The paper is profusely illustrated with curves.

G. E. A.

1893. *Compensated Electromagnet as Standard of Field Strength.* R. Beattie. (Electrician, 73. pp. 929-930, Sept. 18, 1914.)—A compensated electromagnet has been found to be convenient and reliable as a secondary

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standard of field strength or of flux. An opposite flux is imposed on the main flux in the magnet air-gap by means of an auxiliary series winding, the number of turns of which is so adjusted that the compensating flux increases or decreases with changing current at the same rate as the main flux. This is carried out by means of an electromagnet with a double external magnetic circuit each part having its own air-gap. The proper number of auxiliary turns was found by trial, and there was no special difficulty in getting the field in the gap constant to 1 or 2 in 1000 over a range of variation in the exciting current of 100 per cent. or more. With a suitable winding the magnet could be connected up to an ordinary lighting circuit. G. E. A.

1894. *Magnetic Transformation and its Nomenclature.* K. Honda. (Phys. Zeitschr. 15. pp. 705-707, July 15, 1914.)—As a rule physicists have looked on the transformation as a gradual process, whereas many metallurgists have assumed it to be a phase change which took place at a definite temperature. The author refers to the views of le Chatelier, Weiss, and Benedicks, and to his own, expressed recently. Taking the main facts of experiments, it can be concluded that in the temperature interval of the magnetic transformation of ferromagnetic substances an intermolecular change takes place which increases with temperature. The change in magnetisation and the heat phenomenon connected with it are the consequences of this change. This view is supported by the experiments of Charpy and Grenet [Abstract No. 1197 (1908)], of Broniewski [Abstracts Nos. 1498, 1542 (1918)], and of Honda and Ogura [Abstract No. 1188 (1914)]. In conclusion, the author considers that, as the temperature of magnetic transformation is the end temperature of that change, the term "critical point" originally given by Hopkinson is the most suitable one to apply to this temperature. G. E. A.

1895. *Susceptibility of the Binary Alloys.* K. Honda and T. Soné. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 1. pp. 1-14, 1918.)—The present paper, besides dealing with Sb-Bi and Sb-Zn [see Abstract No. 872 (1918)], gives also the susceptibility and melting-point curves for Sb-Al, Sb-Ta, Zn-Te, Zn-Pb, and Bi-Te. The susceptibility of the chemical combination of two metals cannot be deduced from those of the components. G. E. A.

1896. *Thermomagnetic Property of Magnetite.* H. Takagi. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 8. pp. 117-120, 1918.)—The susceptibilities of two specimens of natural magnetite are measured for the temperature range 600°-900°, and the curves for χ and $1/\chi$ with temperature are compared with those of Weiss and Foëx for artificial magnetite. It is concluded that Curie's law is only roughly satisfied, and that there is no internal change of state during heating and cooling. [See Abstracts Nos. 581 (1911), 699 (1918), and 856 (1914).] G. E. A.

1897. *Thermomagnetic Properties of some Elements.* K. Honda and T. Soné. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 1. pp. 27-31, 1918.)—The susceptibility at different temperatures of carbon in the form of diamond, of sulphur in various forms, of manganese and other elements was measured, and the results are exhibited in curves. The curve of the change of susceptibility with temperature of Ceylon graphite is also given. For diamond, graphite, sulphur, manganese, and osmium the susceptibility was independent of the field strength. For Er, Rb, and Se the susceptibility depended on the

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strength of field. The two diamonds examined had the forms of an octahedron and a rhombic dodekahedron, and the susceptibilities at ordinary temperatures were $\chi \times 10^6 = -0.488$ and -0.452 . The susceptibility was independent of the orientation of the crystal. This constant had a value in powdered sulphur and in roll sulphur somewhat smaller than in crystallised sulphur. Some peculiarities in manganese and in graphite were perhaps due to the presence of iron.

J. J. S.

1898. *Magnetic Susceptibility of Soils and Sands*. H. Takagi. (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 1. pp. 15-24, 1918.)—The susceptibility of numerous samples of soils and sands from various places in Japan was measured, and the results are given in a series of tables and curves showing the value at different temperatures. In all the specimens the susceptibilities rapidly decreased with increasing temperature, and became very small between 580° and 600° . It seems very probable that the relatively strong magnetic constituents in soils and sands are the iron compounds. On gradually cooling from the highest temperature attained a reversible change of susceptibility with respect to temperature occurred.

J. J. S.

1899. *Susceptibility and Density of Paramagnetic Substances*. W. H. Keesom. (Konink. Akad. Wetensch. Amsterdam, Proc. 28. pp. 110-122, July 8, 1914. Supplement No. 86c to Communications from the Physical Lab., Leiden.)—The expression from the author's last paper [see Abstract No. 848 (1914)] for the molecular rotatory energy of a system of freely rotating molecules is employed to show that the susceptibility of oxygen in liquid mixtures of oxygen and nitrogen as well as that of liquid oxygen can be represented, within the degree of accuracy of the observations, with the aid of the application of the quantum theory to paramagnetism. The parameter θ_0 , called the characteristic zero temperature, is connected with the higher densities by the law $\theta_0 = a\rho^{2/3}$, where a is constant for a definite substance. [See also Abstract No. 1142 (1914).]

G. E. A.

1900. *Magnetic Study of Iron Sesquioxide*. R. Wallach. (Comptes Rendus, 159. pp. 49-51, July 6, 1914.)—The author has studied the magnetic properties of the following different varieties of ferric oxide: I, prepared by precipitating a warm, freshly-made and very dilute solution of ferric chloride with ammonia; II, Péan de Saint-Gilles' oxide, which is obtained from the above by boiling in water; and III, the oxide produced by the action of water on sodium ferrite, obtained by calcining the precipitated oxide with soda at a dull red heat. By the aid of the Curie-Chéveneau magnetic balance a study has been made of the variations in the susceptibility at temperatures between 15° and 1000° C. The susceptibility of the precipitated oxide at first increases with the temperature, the curve showing a break at 120° and a maximum at 200° . The value then falls rapidly to 800° , then more slowly until it reaches a minimum at 650° C., after which it rises slowly. The Péan oxide curve shows a continual fall, which becomes very rapid between 200° and 350° , at which temperature it joins the first curve. The curve of the ferrite oxide is very similar to the first curve, except that the absolute values are considerably higher. Heating curves taken with the Saladin galvanometer show absorptions of heat at 180° to 150° owing to the removal of water. Oxides I and II show evolutions of heat at 400° , the critical point of II being much less marked than that of I. In the ferrite oxide, however, the evolution does not occur until a temperature of 700° C. has been reached. In common

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with other ferromagnetic materials the diminution of the susceptibility is almost complete before the transformation has taken place, but in this case the change is irreversible. It has also been found possible to render the oxides much more magnetic by thermal treatment just in the same way as it is possible to effect a passing change in the susceptibility. F. C. A. H. L.

1901. *Rôle of Valency in the Additivity of Diamagnetism.* P. Pascal. (Comptes Rendus, 159. pp. 429-481, Aug. 17, 1914.)—The atomic coefficients of diamagnetism for mercury, lead, and tin in organo-metallic compounds vary from maximal values in the lower compounds to minimal ones—virtually identical with the values for the pure metals themselves—in the higher compounds of the series. In plumbic salts the value for the metal is practically equal to this lower limit, whereas in plumbous salts the value is nearly coincident with the upper limit. In stannous sulphate the value for tin is about equal to the minimal value. In halogen salts, such as stannic chloride, the coefficient of specific magnetisation is diminished by 0.0287×10^{-6} for each atom of halogen in the molecule. Mercury exhibits the same atomic coefficient in mercuric as in mercurous salts, this differing markedly from that of the pure metal but being approximately that derived from the initial terms of the organo-mercury series. It would seem, indeed, that mercury is divalent in mercurous salts, those giving rise to the divalent ion, Hg₂. These results are in accord with those of Baker on the vapour densities of dry mercurous chloride [Chem. Soc., Trans. 77. p. 646, 1900] and with those of Ogg on the kinetics of the reduction of mercurous and silver salts by mercury [Abstract No. 852 (1899)].

The neighbourhood of several halogen atoms round a central atom depresses the diamagnetism, owing to the action of supplementary valencies.

T. H. P.

1902. *New Method for Magnetic Determinations.* A. Schuster. (Terrestrial Magnetism, 19. pp. 19-22, March, 1914.)—With the modern development of accurate measurement of electric currents, experiments have been made to determine if magnetic forces can be measured by using artificially prepared magnetic fields for standards of comparison. An instrument has been designed and a number of trials made at the National Physical Laboratory, the result being quite in favour of the method. A standard instrument is to be constructed to allow of a rigid comparison of the accuracy attainable, but in the preliminary work it was found possible to obtain readings of H showing changes remaining practically parallel with the diurnal variation. The saving of time will be one of the chief attributes of the new method. C. P. B.

1903. *Moon's Influence on Terrestrial Magnetism.* S. Chapman. (Terrestrial Magnetism, 19. pp. 39-44, March, 1914. Abstract of paper read before the British Assoc. at Birmingham, 1918.)—Although of minute amount, it is found that certain variations of the barometric pressure and the earth's magnetic field are to be ascribed to the influence of the moon. Thus, for instance, the magnetic variations are greater at times of perigee than at the apogee, there being also some evidence that the ratio of the amplitudes at the two periods is equal to the ratio of the corresponding values of the moon's tide-producing force. At any particular phase of the moon it has been found that the effect of the variable electrical conductivity of the upper air, in conjunction, with the simple semi-diurnal atmospheric oscillation, is to produce magnetic variations of frequency 1, 8, 4, etc., per day, in addition to the

normal 2 periods per day. Further, the epochs of the various components undergo regular changes during the course of the lunar month, all being equal at new moon. These changes with the position of the sun confirm the hypothesis of a variation in the electrical conductivity of the upper air, depending on the solar hour angle. C. P. B.

1904. *The 27-day Period in Magnetic Phenomena.* C. Chree. (Roy. Soc., Proc. Ser. A. 90. pp. 588-599, Sept. 7, 1914.)—The author has shown previously [see Abstract No. 849 (1914)] that since 1890 there has been a decided tendency for the magnetic character of a day, whether disturbed or quiet, to resemble that of a day either 27 days earlier or 27 days later more closely than it does that of the average day. The magnetic character of a day is expressed on the scale 0 (quiet), 1 (moderately disturbed), 2 (highly disturbed). In the present paper the tendency to the 27-day period is examined by discussing the daily ranges at Kew of declination (D), horizontal force (H), and vertical force (V) on the five most disturbed and the five "quiet" days of each month from 1890 to 1900, instead of discussing the character figures of the days, which were employed previously. The method first employed is as follows:—If n is a representative selected day, disturbed or quiet, the percentages of the mean amplitudes are obtained for the amplitudes of each of the components D, H, and V, on each of the days $n-2$, $n-1$, n , $n+1$, $n+2$; $n+25$, $n+26$, $n+27$, $n+28$, $n+29$, $n+30$. The results are set out for each year and for the whole period, and for each component, with reference both to disturbed and quiet days; and in a final table the means of the three components are given for the individual years and the whole period. The following average values are quoted:—

PERIOD 1890-1900: MEANS OF D, H, AND V RANGES.

Percentages of Mean Absolute Daily Ranges.

$n-2$	$n-1$	n	$n+1$	$n+2$	$n+25$	$n+26$	$n+27$	$n+28$	$n+29$	$n+30$
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Days of Largest Range and Associated Days.

108.6	134.4	189.7	129.9	107.7	100.4	108.1	115.2	113.6	108.1	106.3
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Quiet Days and Associated Days.

91.2	80.5	69.7	89.8	108.8	93.7	88.9	89.9	92.0	95.5	98.0
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These figures suggest a "period" slightly longer than 27 days in the case of disturbed days, and slightly longer than 26 days in the case of quiet days.

The matter is also considered by noting the number of times that the selected disturbed or quiet days are separated by intervals of 27 or 28 days, but a difficulty enters in of deciding which disturbances form such sequences and which do not, and renders this method less trustworthy than the former method outlined above. R. C.

1905. *Time Measurements of Magnetic Disturbances.* C. Chree. (Phys. Soc., Proc. 26. pp. 187-158; Discussion, p. 153, April, 1914.)—The discussion was introduced by Bauer, who considered the records provided evidence that a definite interval was occupied in the movement of magnetic disturbances to different parts of the earth's surface. Later Faris discussed the records of 15 magnetic disturbances, his conclusion being in support of Bauer's theory that the velocity of propagation was of the order of 100 km. per sec.

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Chree's view was that the results can only be satisfactory when observations are secured from a number of stations encircling the earth, and Bauer then collected data from 80 stations. The analysis of the horizontal force curves from these, by Angenheister, proved unfavourable to Bauer's view.

The present paper deals with the material by a different method, and utilises the declination and vertical force curves in addition to those of horizontal force. The results bring out peculiarities which may be due to instrumental peculiarities, and emphasise the need of magnetic observatories being equipped with similar instruments, which should be capable of keeping records to a tenth of a second.

C. P. B.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1908. *Visual Sensation caused by a Magnetic Field.* C. E. Magnusson and H. C. Stevens. (Phil. Mag. 28. pp. 188-207, Aug., 1914.)—The chief results of the author's former work are briefly summarised. The purpose of this paper is to present the results of experiments which aimed at the solution of a single problem, viz. the dependence of the threshold of the light sensation upon the frequency of the current. Knowing the relatively simple law which W. Nernst and his pupils found to exist between the minimal effective stimuli of alternating currents of high frequency and the intensity of the current, it is hoped to discover a similar simple relationship between frequency of alternation of the magnetic field and the minimal effective intensity of current just sufficient to cause the sensation of light. Nernst's law, $K = i/\sqrt{f}$, where K is a constant, i the minimal intensity of current just sufficient to excite a motor nerve such as *n. ischiadicus* of the frog, and f the frequency of the current, holds good for a large number of results. It applies, as Nernst has shown not only to motor but also to sensory nerves. If the mode of excitation of a nerve by the alternating magnetic field is similar to the mode of excitation of a nerve by the alternating electric current, we might reasonably expect the same law to hold for both phenomena. It is shown that such an expectation is not justified. Full details are given of the coil and strength of field used, together with complete data (in both tabular and graphical form) of the observed results.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1907. *Rate of Solution of Hydrogen by Palladium.* A. Holt. (Roy. Soc., Proc. Ser. A. 90. pp. 226-287, May 1, 1914.)—The rate of solution of hydrogen by palladium is not a simple function of the concentration of gas in the metal. The rate curves consist of two portions (except in the case of palladium black), which are interpreted as referring to solution in two different forms of the metals. The smooth rate curve for palladium black is taken to mean the almost complete absence of one of these forms. T. M. L.

1908. *Crystalline Structure of Copper.* W. L. Bragg. (Phil. Mag. 28. pp. 855-860, Sept., 1914.)—It was found possible, by treating with acid the prepared faces of a natural crystal of copper to obtain crystal faces which could be used as reflectors in the X-ray spectrometer. When the crystal was placed in nitric acid until the surface was eaten away to an extent of perhaps $\frac{1}{4}$ mm., the faces were etched deeply into numerous parallel facets, which all reflected the light simultaneously in the usual way. This suggested that, internally, the crystal structure was perfect, and showed further that in some cases the whole specimen was composed of a single crystal. This method of obtaining a crystal surface was suggested by some previous experiments on zincite. The results of the investigations show that in a copper crystal the atoms are arranged on face-centred cubic lattice. This is the close-packed lattice to which attention has been drawn by Pope and Barlow. The crystal structure is the most simple of any as yet analysed. A. W.

1909. *Radio-active Elements.* F. H. Loring. (Chem. News, 109. pp. 241-242, May 22, 1914.)—It seems probable that the radio-elements are made up of associated atoms differing in atomic weight, and that these are exactly whole numbers taken from a Rydberg atomic weight series. The branching in the thorium series at ThC suggests the possibility that at this point the associates virtually part company, and that the respective end products may be considered as consisting of homogeneous whole-number atomic-weight atoms, standing in proportionate numbers to each other in the same ratio as the products ThD and ThC₂, namely 5 : 9. Then thorium itself should be a mixture (ThII 285)₅ + (ThI 281)₉. The mean value is 282.428, which is in agreement with the present accepted value for thorium, 282.42. The author arranges the radio-active elements in a table based on this principle, which indicates that the emanations of actinium and radium are possibly homogeneous, the former consisting entirely of atoms of atomic weight 228, and the latter 219. E. E. F.

1910. *Interatomic Forces and Chemical Affinity.* J. J. Thomson. (Phil. Mag. 27. pp. 757-788, May, 1914.)—Even in and around neutral atoms, if consisting of electrons and positive electricity, there will be a field of force varying with the electrical distribution within the atoms, and methods of representation have been developed by Sutherland, Einstein, and Kleeman. Only when every atomic molecule is neutral can the forces exerted by the molecule be represented as the resultant of forces due entirely to doublets within the atoms. In molecules containing oppositely charged atoms, VOL. XVII.—A.—1914.

doublets with poles on different atoms will also come into play. Chemical compounds should therefore fall into two classes accordingly, possessing strikingly different properties, for the separation of the poles, and corresponding increase in the movements, of doublets lying on two atoms should give rise to increased intermolecular forces, corresponding to higher intrinsic pressure, surface tension, and dissociating powers. The author quotes evidence from his *Rays of Positive Electricity* suggesting the existence of substances consisting of neutral atoms, *e.g.* CO, and also that such atoms, when combined with suitable atoms, may draw a negative charge from them, thus by *intra-molecular ionisation* giving rise to oppositely charged atoms. The setting of doublets in the electric field will increase the specific inductive capacity, and, involving molecular rotations, will diminish response to light vibrations, so that in compounds containing charged atoms high specific inductive capacity is to be expected with refractive indices less than accord with Maxwell's law. This is confirmed by Bädeler's observations [Abstract No. 1111 (1901)], and, as here shown mathematically, the abnormal specific inductive capacity should decrease with increasing temperature, which Bädeler's results confirm. These considerations also account for the exceptional powers of alcohol and water, shown by Bädeler to have abnormally high specific inductive capacity, to attract and bind corpuscles and so diminish mobility of negative ions in gases. Taking the relation $K = n^2$ as criterion of absence of inter-molecular ionisation, some typical gases fall into the two classes of the accompanying table; I, Neutral Atoms; II, Charged Atoms.

- I. $H_2, O_2, N_2, He, Cl_2, CO, CO_2, CS_2, CCl_4, C_6H_6, CH_4, N_2O$.
 II. $H_2O, NH_3, SO_2, HCl, CH_3OH, C_2H_5OH, CH_2Cl, CHCl_3$ (slight).

The effect on K of varied orientation in the doublets forming constituents of chemical compounds is considered, and illustrated by graphic formulæ of existing compounds, also the effect of varying the proportions of charged and uncharged molecules, and it is suggested that OH acting as an acid is of type $\bar{O} - \overset{+}{H}$, and of type $\bar{O} - H$ when basic.

The aid afforded to intra-molecular ionisation by the presence of extraneous charged atoms is very simply shown. Simple enumeration of the conditions for intra-molecular ionisation shows that it will occur only in a certain type of molecule, and only molecules with certain properties can produce it. Consideration of the chemical effects of the electric fields arising from intramolecular ionisation points to the existence of the *molecular compounds* which chemists have recently been disposed to throw doubt upon. Conduction in gases affords evidence of condensation of the gas around molecular doublets, ascribable to their strong electric fields. It is true that ordinary ionisation of a gas does not appear to accelerate chemical action, but this is explained by the small proportion of gas affected. In regions of intense ionisation, *e.g.* in the negative glow in a discharge tube, all kinds of chemical action seem to go on with great facility.

Considering the possibility of an active molecule, viz. one of exceptionally large electrostatic moment, holding one or more molecules of a different kind in combination, thermodynamic considerations lead to the conclusion that the permanent existence, at ordinary temperature, of such compounds will probably be possible only for a limited number of types of molecules. The addition of further attached molecules will render the resulting compound increasingly unstable, so that there will be a definite limit to the

number of molecules that can be so bound, *e.g.* the number of molecules of water of crystallisation is never large. Liquids whose molecules have large electric moments may be expected to produce great ionisation when electrolytes are dissolved in them, as is confirmed by Walden [Abstract No. 806 (1906)]. Electrification by bubbling is to be expected only in case of compounds containing charged atoms, and this agrees with Bloch's experiments [Ann. Chim. Phys. 28. p. 28, 1911]. Investigation of valency and of the conditions for the existence of a chemical compound leads to a modification of Abegg's theory of positive and negative valency, differing from it in that while the atom can exert either valency it cannot bring both into play at the same time. The existence of unsaturated compounds does not constitute any difficulty, the question being why other analogues do not exist, and it is suggested that this may find its solution in the effect of the strong electric field in the neighbourhood even of a saturated atom restricting the freedom of motion of the corpuscles in neighbouring atoms.

G. W. DE T.

1911. *The Allotropy of Zinc*. E. Cohen and W. D. Helderman. (Konink. Akad. Wetensch. Amsterdam, Proc. 28. pp. 59-60, July 8, 1914.)—In an earlier paper the authors have pointed out the possibility of the metals atomised by the Schoop process existing in several allotropic forms [Abstract No. 992 (1914)]. Dilatometric experiments carried out on a large quantity of zinc atomised by the Schoop process show that a marked contraction takes place after a very few hours at the ordinary temperature. Tests carried out on zinc oxide showed that the contraction could not be attributed to reaction between the paraffin used in the dilatometer and any zinc oxide which may possibly exist in the atomised zinc.

F. C. A. H. L.

1912. *Formation of Neumann Lines*. Matwieieff. (Rev. de Métallurgie, 11. pp. 766-770, July, 1914.)—In examining half-rolled samples of very soft steel with the naked eye after carefully polishing, the author has often observed straight lines which recall Neumann lines. This opinion was confirmed by H. le Chatelier after examining a number of photomicrographs submitted to him. Le Chatelier suggested that the lines were produced by the friction of the emery in those grains in which the cleavage planes were parallel to direction of rubbing. The lines are interrupted where they traverse grains of different orientation, but reappear further on in grains which probably form branches of the same dendrite. On the advice of le Chatelier experiments were carried out to prove that the grains in which the lines ran in the same direction possessed the same orientation. By progressive etching in 2% nitric acid in a mixture of equal parts of ethyl and amyl alcohols this was found to be the case. The results appear to indicate that the Neumann lines indicate the orientation of the grains and the direction of corrosion. The orientation of the Neumann lines in each grain form Widmanstätten figures: Neumann lines are in relief on the surrounding metal.

F. C. A. H. L.

1913. *Microscopic Study of Electrolytic Iron*. O. W. Storey. (Amer. Electrochem. Soc., Trans. 25. pp. 489-527, 1914.)—By double electrolytic refining of American ingot iron in an electrolyte of iron sulphate and ammonium chloride, using a current of 10 amps. per sq. ft. it is possible to get a material containing 99.971% Fe, the main impurities being hydrogen, carbon, and silicon. The crystals are propagated in a plane perpendicular to the surface of the kathode and gradually increase in size as they get further

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away from the sheet. As deposited, electrolytic iron is brittle and dissolves in acids more rapidly than zinc. This is probably due to the presence of occluded hydrogen since after heating to about 600°C. , when a rapid evolution of hydrogen takes place, the metal becomes ductile and is much more slowly attacked by acids. No change is effected in the microstructure by heating at temperatures below the A8 range. Above A8, however, a change in the microstructure is effected, the rate of the change depending on the fineness of the deposit. A short heating converts the fine deposit into the typical structure of ordinary ferrite, while a coarse deposit becomes coarse-grained. These coarse grains can be refined by heating to 1000°C. , or by prolonged annealing at the Ac8 point. No appreciable growth takes place at 1150°C. Prolonged etching of fused electrolytic iron revealed coarse grains each of which contained an inner grain structure. The boundaries of the coarse grains are V-shaped grooves, while those of the inner grains are shallow depressions. These inner grains are only destroyed by several annealings above the Ac8 point. The large grains are probably the gamma grains which split up during cooling into a large number of similarly oriented non-gamma nuclei forming the inner grain structure. F. C. A. H. L.

1914. *Velocity of Transformation of Steel on Heating and the Specific Resistance of Iron.* A. Portevin. (Comptes Rendus, 159. pp. 61-58, July 6, 1914.)—On quenching steel the electrical resistance is increased owing to the retention of a certain amount of carbon in solution. The amount retained can be calculated from Benedicks' formula $\Delta p = 26.8 C$, where Δp represents the increase in the resistance. Since the amount of carbon passing into solution at any predetermined temperature is a function of the time for which the steel is heated at this temperature, assuming constant rates of cooling, the velocity of the transformation at any particular temperature can be determined by observing the resistance of specimens quenched under identical conditions after being kept at the temperature for varying periods of time. This has been done for steels containing from 0.17 to 1.08 % carbon. The result shows that the solution of carbon on heating is far from being an instantaneous process. The increase in resistance of a 0.88 % carbon steel after heating to 750°C. for 2 minutes and quenching was 8.28 microhms-cm. while after 10 minutes at the same temperature the increase was found to be 18.28 microhms-cm. For this steel the state of equilibrium does not appear to be attained after 10 minutes at 750° , since after 10 minutes at 900° the increase was 20.06 microhms-cm. It is only fair to add that the increase in the quenching temperature facilitates the retention of the carbon in solid solution. Increase in the temperature or in the duration of the heating increases the resistance either by modifying the final state of equilibrium or by affecting the velocity of the reaction. By extrapolation from a series of results obtained with hypoeutectoid steels quenched in water after heating to 1000°C. for 10 minutes the author has obtained the value 9.8 microhms-cm. for the specific resistance of pure iron. This value closely agrees with the figures obtained by a number of workers, but differs considerably from the 7.6 value obtained by Benedicks. F. C. A. H. L.

1915. *Changes in Mild Steel during Annealing.* A. Stadelcr. (Ferrum, 11. pp. 271-276, June 8, 1914.)—A Siemens-Martin mild steel whose average composition was C, 0.10 % ; Mn, 0.45 % ; P, 0.026 % ; and S, 0.048 % was rolled into plates 15.5 mm. in thickness. Complete homogeneity was proved VOL. XVII.—A.—1914.

by making numerous analyses, impact tests and micrographic examinations. This material was then annealed in a coal-fired furnace at the usual temperatures adopted in practice for the annealing of plates, viz. 860°C ., the max. temperature never being allowed to rise above 900° . After periods of annealing varying from $1\frac{1}{2}$ to 600 hours the samples were cooled slowly and examined for variations in thickness, resilience, and microstructures. In spite of the fact that the atmosphere of the furnace always contained an excess of CO, a certain amount of scaling took place, the plates losing about 12.8 % in thickness during 600 days. After 15 days the material was practically decarbonised: the manganese and phosphorus remained constant over the whole period, while the sulphur remained constant for 8 days and then slowly increased. Resilience increased during the first $1\frac{1}{2}$ hours' heating; it then fell somewhat and after 14 days began to increase again. Grain growth, as revealed by microstructure, was more rapid and greater on the outside than in the middle of the specimen. This is undoubtedly to be ascribed to the cold working on the outside of the plates. For material of the same composition the resilience decreases as the grain size increases, but, naturally, as the carbon becomes oxidised away the resilience increases accordingly. After internal stresses have been removed, the grain growth becomes a function of the time.

F. C. A. H. L.

1916. *Effect of Carbon, Silicon, Cobalt, and Copper on the γ - δ Transformation of Pure Iron.* R. Ruer and R. Klesper. (Ferrum, 11. pp. 257-261, June 8, 1914.)—Earlier researches on the Fe-Co and the Fe-Cu systems have indicated that in addition to the three well-known allotropes of iron there exists a fourth (δ) modification, which is stable above 1400°C . A cooling curve of electrolytic iron containing 99.96 % Fe showed that solidification occurred at 1528°C ., and that there was a well-marked evolution of heat at 1401° . Addition of carbon rapidly raises the temperature of this change, lowers its intensity, and at the same time increases the tendency towards undercooling. At 0.1 % carbon the temperature of the change becomes constant at 1487° , and the horizontal line joins the liquidus at 0.4 % carbon. Silicon decreases the temperature of the change, at first slowly and then more rapidly as the content of Si increases: 1.2 % Si lowers the temperature to 1386° . Cobalt raises the critical point to 1492° at a concentration of 18 %; the temperature of the change then remains constant up to a concentration of 25 %, at which it becomes coincident with the solidification point. Copper behaves in an exactly similar manner, 6.5 % raising the critical point to 1475°C . At this point it becomes constant and joins the liquidus at a concentration of 18 % copper. The authors consider that this research conclusively proves the existence of the δ modification of iron, and that it will serve as a basis of explanation of discrepancies in the results of various workers on the changes occurring in iron at high temperatures.

F. C. A. H. L.

1917. *Hardness and Electrical Resistance of Iron-Carbon Alloys.* R. Vondráček. (Int. Zeitschr. Metallog. 6. pp. 172-182, May, 1914.)—The theory of Andrew [Abstract No. 1351 (1914)] to the effect that the extraordinary hardness of martensite is due to the existence of exceedingly finely divided cementite embedded in a ground mass consisting of austenite containing a little ferrite is not in agreement with the laws laid down by Kurnakow and Zemčuzny, who have shown that the hardness of a mixture is the arithmetic mean of the hardnesses of its constituents. Now the researches

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of Maurer have shown that the hardness of carbon-rich austenite is not appreciably greater than that of ferrite, so that the hardness of martensite as defined by Andrew should be very little greater than that of pearlite. Conductivity measurements of quenched steels show that practically the whole of the carbon exists in a state of solution.

The author considers that hardness is a function of the transformation, owing to the α -iron not being able to assume its proper orientation. The quenched metal, therefore, has an open, non-oriented structure, which accounts for the lowering of the density and the increase of the hardness. In this form the theory is similar to the amorphous theory as applied to cold-worked metals. From a detailed consideration of the results of le Chatelier, Gumlich, and Benedicks on the resistance of iron-carbon alloys the author concludes that the specific resistance of cementite is about 88.5 microhms.-cm., and that the ferrite in hypereutectoid steels has an appreciable carbon-content which increases as the total carbon increases. It is also concluded that the eutectoid ferrite contains from 0.06-0.07 % carbon at the eutectoid temperature, and that this content increases with falling temperature until it attains a maximum of 0.14 % at 600° C.

F. C. A. H. L.

1918. *Structure, Faculty of Recrystallisation, and Resistance of Electrolytic Copper.* O. Faust. (Zeitschr. anorg. Chem. 78. pp. 201-212, 1912. Rev. de Métallurgie, 11. pp. 890-894, June, 1914.)—Experiments have been made to determine if the electrodes affected the product during the electro-deposition of copper at ordinary temperatures. The electrodes used were iron, coarsely crystalline white iron, bismuth and antimony, wood charcoal and gas carbon. The structure of the copper appears to be independent of the material of the kathode, and there is no correlation between the crystals of the electrode and those of the deposit. The current density and the concentration of the copper ions, however, exercise a considerable influence. The results obtained were purely qualitative, but show that the size of the crystals decreases with increase of current density and with decrease of ionic concentration. This accounts for the small crystals obtained in the technical method of depositing copper. With low current-density the copper deposited is ductile, while with high density the deposit is brittle. Microscopic examination shows that the structure of electro-deposited copper consists of crystals having a parallel orientation. Annealing causes a considerable increase in growth, but the crystals still retain their parallel orientation. The ultimate size of the crystals is practically the same as that attained in the case of deformed cast copper and does not appear to depend on the method of production. Apart from bismuth and antimony, the difficulty in the way of studying the vectorial properties of metals lies in the trouble experienced in obtaining crystals of sufficient size. On account of the parallel orientation of the crystals, electro-deposited metals appear to be suitable for this study, and the author has therefore determined the lower elastic limit of electro-deposited copper in directions parallel to and at right angles to the direction of growth of the crystals, by the method of Faust and Tammann. The values obtained were 687 kg./cm.² and 680 kg./cm.² respectively. Slowly cooled cast copper shows a value of 205 kg./cm.². The difference may be ascribed to the presence of cuprous oxide in the cast copper and to the presence of occluded hydrogen in the electrolytic product. After annealing *in vacuo* for 1 hour at 1000° C. the lower elastic limit of the electrolytic copper fell to 205 kg./cm.², but this decrease is to be ascribed to structural changes rather than the removal of impurities. In electrolytic copper the

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gliding planes produced by straining are not wholly normal to the direction of the crystal growth, but are always visible in two directions. These two directions may appear at the same time in the same crystal, are always equally inclined to the direction of the current, and are found on almost every surface of the sample. The surface in contact with the electrode shows smaller crystals than the surface which was in contact with the electrolyte. Annealing does not alter the direction in which gliding planes are produced after straining.

F. C. A. H. L.

1919. Copper in Steel: Influence on Corrosion. D. M. Buck. (Journ. Indust. and Engin. Chemistry, 5, pp. 447-452, 1913.)—The steels used were two basic open-hearth steels, containing respectively: C, 0.10; Mn, 0.34; S, 0.084; P, 0.019; and C, 0.18; Mn, 0.45; S, 0.086; P, 0.042; and one Bessemer steel containing C, 0.08; Mn, 0.46; S, 0.070; P, 0.092. The amount of copper added was sufficient to give a copper content of either about 0.15 or 0.25 %. The steels with and without copper were put through the same mill operations, and were finally obtained as corrugated strips, which were tested for atmospheric corrosion at three different stations: (1) in the Pennsylvania Coke regions, where the air contains notable amounts of sulphurous and sulphuric acids, etc.; (2) on the sea coast; (8) in the country. The strips were put on open sheds and exposed to the atmosphere on all sides, the time of the test lasting for several months; observations were made from time to time. Full details are given with respect to each test-piece. As a general result it may be considered as proved that copper has a very beneficial effect in retarding corrosion; the copper-containing steels resist the atmosphere from one and a-half to two times as well as normal steels without copper, and there is little or no difference in the average between a copper content of 0.15 and 0.25. Accelerated acid tests gave similar results but it should be pointed out that in some cases the results of the acid tests are directly opposite to the results of the atmospheric tests.

T. S. P.

1920. Positive Ions from Non-metallic Elements. I. Precipitation of Metals from Solutions of their Salts by Yellow Phosphorus. R. M. Bird and S. H. Diggs. (Amer. Chem. Soc., Journ. 86, pp. 1882-1892, July, 1914.)—The principal products of the action of yellow phosphorus on solutions of copper sulphate are copper and phosphoric acid, which are accompanied by small proportions of (1) copper phosphide, which results from the action of the precipitated copper on the phosphorus, and (2) phosphorous acid, which is due to the interaction of the phosphorus and the phosphoric acid originally formed. The quantitative results obtained are in accordance with the equation, $5\text{CuSO}_4 + 2\text{P} + 8\text{H}_2\text{O} = 5\text{Cu} + 2\text{H}_3\text{PO}_4 + 5\text{H}_2\text{SO}_4 + 2\text{H}_2\text{O}$, and since the copper is formed only on the surface either of the phosphorus or of a conductor connected with the phosphorus, the action appears to be electrolytic in character and to be represented by the equations, $5\text{Cu}^{++} + 2\text{P} = 5\text{Cu} + 2\text{P}^{++++}$ and $2\text{P}^{++++} + 10\text{OH}^- = 2\text{P}(\text{OH})_3 + 2\text{H}_3\text{PO}_4 + 2\text{H}_2\text{O}$. This conclusion is corroborated by the observation that, in a cell consisting of a copper electrode immersed in 0.5N copper sulphate solution and a phosphorus electrode immersed in dilute sulphuric acid, the phosphorus is always negative to the copper, the e.m.f. of the cell being about 0.85 volt; little difference on the resulting current is made by varying the concentration of the sulphuric acid or by replacing the latter by distilled water, or a solution of magnesium sulphate or zinc sulphate or one from which the copper has been precipitated by phosphorus.

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The conclusion is drawn that, in displacing certain metals from their salts, phosphorus first passes into solution as a positively charged ion, in the same way as do the metallic elements, the chief distinction between the so-called non-metallic and the metallic elements depending upon the tendency of the former to hydrolysis and the subsequent ionisation of the hydrolytic product, rather than upon the ability to form positive ions. Experiments are being conducted to ascertain if this property of phosphorus is general with non-metallic elements.

T. H. P.

1921. *Electrical Conductivity of Bromine Solutions of Iodine.* W. A. Plotnikow and V. E. Rokotjan. (Russian Physico-Chem. Soc., Journ. 45. pp. 198-199, 1918.)—The authors have measured the conductivities of solutions of iodine in bromine with concentrations of 0-44.5 % I (or 72.28 % of BrI) at 25°, and of 44.5-59.48 % I at 40.6°. The specific conductivity at 25° increases continuously from $\chi_{25} \times 10^6 = 0.82$ for 12 % of I to 126 for 44.5 % of I. The molecular conductivity diminishes uninterruptedly with increase of dilution. With rise of temperature the conductivity increases, the extent of the change being greater for dilute than for concentrated solutions. These results are explained by the formation of an iodine bromide and its dissociation into bromine and iodine ions. The marked electrical conductivity of bromine solutions of iodine does not agree with the view that conductivity is conditioned by appreciable increase in the dielectric constant of the solvent. Comparison of conducting solutions of iodine in bromine with non-conducting solutions of potassium bromide in bromine indicates the invalidity of the hypothesis which regards electrolytes as divisible into "good" or "typical," such as potassium bromide, and "bad." Electrical conductivity must, indeed, be considered as a consequence of the electrochemical relations of the solute with the solvent.

T. H. P.

1922. *Influence of the Current Frequency and Temperature on the Yield of Ozone.* N. Puschin and M. Kauchtshev. (Russian Physico-Chem. Soc., Journ. 46. pp. 576-590, 1914.)—With constant periodicity up to 800 per sec., the yield of ozone increases with increase of the voltage from 6500 to 8000. When the frequency is varied, but the voltage and other conditions kept constant, the yield of ozone increases as the frequency is increased to 1240 \sim per sec. at 6500 volts, to 950 at 7000 volts, and to 660 at 8000 volts; if the rate at which the air passes through the ozoniser remains the same, increase of the frequency beyond these limits is accompanied by diminution of the yield of ozone. Continued increase of the air current displaces the max. yield towards continually increasing frequencies. Rise of temperature from 0° to 28° causes the yield of ozone to increase, but further rise diminishes it.

T. H. P.

1923. *Theory of the Rotatory Power of Liquids.* A. Mazzucchelli. (Gazzetta Soc. Chim. Ital. 44. 1. pp. 410-417, 1914.)—According to van't Hoff's theory and to Gbye's results, the rotatory power of a substance depends on the degree of asymmetry of the molecule, but since this varies with the orientation of the molecule, it would seem that the observed rotatory power represents the mean of a number of values differing more or less among themselves. If, therefore, the molecules can be constrained wholly or partly to assume a definite orientation, the optical activity should be changed. With the liquid crystals examined by Vorländer [Ber. Deut. Chem. Gesell. 41. p. 2068, 1906]; the great superiority of the rotations over those

exhibited by the same compounds in solution renders it probable that the liquid crystal consists of an asymmetric aggregate of many simple molecules. That liquid crystals are highly polymerised is, indeed, indicated by their relatively slight solubility.

In the case of an electrolyte, the charges of the ions are regarded as localised at certain points occupying invariable positions in the molecule. If the electrolyte is optically active, the action of a current passing in the direction of the ray of polarised light constitutes a force applied only at one portion of the molecule, and should hence tend to orientate the latter in a definite direction. Any variation in the rotation would depend solely on the direction, and not on the sense, of the electric field, since, according to Helmholtz's principle of reciprocity, all modifications produced in a ray of light in its passage through any medium are independent of the direction of that passage. Experiments made with solutions of potassium uranylmalate showed, however, that the passage of a current is accompanied by no appreciable alteration in the rotation. The author draws the conclusion, which is confirmed by calculation, that the directive force of the current is very small in comparison with the active forces exerted between the molecules.

T. H. P.

1924. *Analysis of very Small Quantities of Gas ; Application to the Analysis of Air.* P. A. Guye and F. E. E. Germann. (Comptes Rendus, 159. pp. 154-157, July 18, 1914.)—An apparatus is described by means of which quantities of gas of the order of a few cubic millimetres may be accurately analysed. It is hoped to increase the sensitiveness of the method to such an extent that 1-2 c.cm. of air will suffice for a series of estimations, a result which would be of great importance in connection with the chemical investigation of the atmosphere at high altitudes. [Errata. Ibid. p. 292, July 20, 1914.]

T. S. P.

1925. *Compressibilities of Solutions of Inorganic Salts.* W. Watson. (Roy. Soc. Edinburgh, Proc. 88. pp. 282-291, 1912-1918.)—With a view to testing whether the formula from which Tammann calculates the internal pressures is satisfied at high pressures, the author has measured the densities and compressibilities of twenty-one solutions of normal concentration or under; a series for water being also taken. Some of the results obtained by Tammann (from expansibility) are compared with some of the author's results from compressibility, and good agreement is shown. The question of relative molecular depression of the freezing-point is also briefly discussed.

L. H. W.

1926. *Work done in Formation of a Surface Transition Layer of a Liquid Mixture.* R. D. Kleeman. (Cambridge Phil. Soc., Proc. 17. No. 5. pp. 409-418, May, 1914.)—The expression obtained [see Abstract No. 848 (1918)] from surface tension considerations is here applied to mixtures of certain liquids.

L. H. W.

1927. *Thermodynamic Potential as a Kinetic Quantity.* H. Hulshof. (Konink. Akad. Wetensch. Amsterdam, Proc. 28. pp. 85-91, July 18, 1914.)—Mathematical.

T. H. P.

1928. *The Ideal Diffusion Coefficient and a Fundamental Law concerning the Diffusion of Dissolved Substances.* G. McP. Smith. (Amer. Chem. Soc., Journ. 86. pp. 847-864, May, 1914.)—The diffusion coefficient D is derived

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from the formula $dS = -Dq \cdot dc/dx \cdot dt$, in which dS is the quantity of the dissolved substance which passes at the point x in the time dt through the cross-section q of a diffusion cylinder under the influence of the concentration fall dc/dx . The value of D depends upon the temperature and upon the actual concentration. The author proposes to describe as the *ideal diffusion coefficient*, I , the ratio D/M of the ordinary diffusion-coefficient to the molecular weight, and states that this coefficient indicates the number of mols. of a compound which in the unit cross-section would pass in unit time through the unit molal concentration-interval with unit velocity.

Values plotted for a series of compounds show a linear relation between M and $\log I$, so that for many substances

$$M = (K/D)^{1/n-1}.$$

Thus for a series of solids diffusing in water $n=1.4894$, and $K=6.66$. For gases in water $n=1.5826$ and $K=\text{about } 10$. For metals in mercury $n=1.4588$, $K=18.9$. This equation appears to represent a fundamental law of diffusion. Since n does not differ much from 1.5 it leads approximately to Exner's rule that $DM^{1/3} = \text{const.}$

T. M. L.

1929. *Negative Osmose*. F. E. Bartell. (Amer. Chem. Soc., Journ. 86, pp. 646-656, April, 1914.)—Salt solutions of sulphates, chlorides, nitrates, and acetates were placed in osmotic cells constructed of porcelain of the same degree of porosity. Whilst some of the solutions gave positive osmose, others gave negative osmose, i.e. the direction of flow was from the concentrated to the more dilute solution. The flow of the solution as a whole through the membrane, in the experiments with nitrates and chlorides, was toward the more dilute solution, when the anion had a greater migration velocity than the kation; the rate of flow increased with the difference between the migration velocities of anion and kation. The appearance of negative osmose is dependent on the pore diameter of the membrane. Negative osmose of $MgCl_2$ predominates only when the pore diameters are somewhat less than 0.4μ . Negative osmose appears to depend on electrical polarisation of the capillaries brought about through ionic adsorption by the membrane.

T. M. L.

1930. *Absolute Measurement of Coefficients of Adsorption*. J. Bancelin. (Comptes Rendus, 188, pp. 791-792, March 16, 1914.)—Measurements were made of the adsorption of substances on glass surfaces of known area. The quantities of a colouring-matter adsorbed were 2×10^{-6} and 14×10^{-6} grains per sq. cm. when the concentrations were 10^{-6} and 10^{-8} gm. per c.cm. respectively. In the case of common salt, the adsorption was 14×10^{-8} gm. per sq. cm. at a concentration of $N/10,000$. Other salts gave analogous results.

T. M. L.

1931. *Molecular Magnitude and Electrical Conductivity of some Fused Salts*. P. Walden. (Acad. Sci. St. Pétersbourg, Bull. 6, pp. 405-422, April 1, 1914.)—A series was selected of organic salts which melt at very low temperatures and could therefore be studied by the methods used already for aqueous and non-aqueous solutions. Four substituted ammonium nitrates gave at $100^\circ C$. association-factors ranging from 4 to 9; three other fused salts resembled water in giving values approaching 2. The surface tension of the fused salts was high, the lowest of six values being about one-half that of water. All the salts were at least 10 times more viscous than water, but two bromides were over 140 times more viscous. The electrical conductivity of five salts

increased according to a linear law with rise of temperature, the molecular conductivity being greatest when the viscosity was least, and the temperature coefficient being greatest when the viscosity was greatest. The organic salts at low temperatures behave just like the simple inorganic salts at high temperatures. In view of the associated character of the salts there can be no question of dissociation into simple ions, but the fused salts may well contain complex ions as in the case of aqueous and other electrolytic solutions.

T. M. L.

1932. *Dissociation of Hydrogen into Atoms. Part I. Experimental. I. Langmuir and G. M. J. Mackay.* (Amer. Chem. Soc., Journ. 86. pp. 1708-1722, Aug., 1914.)—Earlier experiments on the convection of heat from wires of different kinds in various gases [see Abstracts Nos. 887A, 827B (1912)] led to a general theory of convection from hot bodies which renders possible the approximate calculation of heat losses from a wire at any temperature in any gas which behaves normally. The fact that at high temperatures the observed heat loss in hydrogen increases rapidly until it greatly exceeds the calculated value led to the suggestion that the hydrogen is partly dissociated into atoms at these temperatures. Application of a development of the theory of heat conduction in a dissociating gas indicated that at atmospheric pressure this dissociation amounts to 1.2 % at 2800°, 44 % at 3100 and 84 % at 3500° K, the heat of formation of the molecules from the atoms being given as 180,000 cal. per 2 gm. of hydrogen; this result conflicts seriously with the measurements of the specific heat of hydrogen by the explosion method. In addition to this qualitative evidence of the dissociation of hydrogen there is a large amount of chemical evidence proving indubitably that when hydrogen at low pressures comes into contact with a heated metallic wire, the gas is chemically activated, and that it can, under suitable conditions, retain its activity for several days. But as there is good reason to suspect that the actual values for the degree of dissociation previously given are considerably too high, probably owing to an incorrect assumption concerning the diffusion coefficient of hydrogen atoms through molecular hydrogen, two methods independent of such assumption have now been employed to obtain more or less quantitative data on the dissociation.

The first of these is based on measurements of the total heat losses from tungsten wires at a series of different pressures, ranging from 10 mm. to atmospheric pressure. The results show that, even at the lowest pressure employed, the temperature coefficient of W_0 —that part of the heat loss dependent on the dissociation of the gas—is practically as great as at atmospheric pressure, so that even at these low pressures the hydrogen around the wire is not nearly completely dissociated; these experiments give, however, an upper limit to the degree of dissociation.

In the second method similar measurements were made at very much lower pressures, varying from 0.01 to 0.2 mm. At the lowest pressures the molecules travel in straight lines directly from filament to bulb, and the hydrogen atoms produced practically never return to the filament without having struck the bulb many times and having had ample opportunity to recombine. If, by heating the filament to very high temperatures, a condition could be reached such that every hydrogen molecule striking the filament becomes dissociated, these measurements would lead to a direct determination of the heat of formation of hydrogen molecules; in the absence of definite evidence that the dissociation is complete, the method gives at least a lower limit for the heat of formation.

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Experiments made with nitrogen and with hydrogen show a very striking difference between the effects in the two cases. In nitrogen the values of the power consumption decrease steadily as the pressure is reduced, and the same is the case, at the lower temperatures, in hydrogen; but in the latter gas at higher temperatures the power consumption is considerably greater at lower pressures than at atmospheric pressure. At very high temperatures the value of W_D for hydrogen increases very rapidly and becomes 50 or 100 times as large as the possible experimental error. T. H. P.

1933. *Transference Number, Conductance, and Ionisation of Hydriodic Acid at 25°*. E. K. Strachan and V. G. Chu. (Amer. Chem. Soc., Journ. 86, pp. 810-819, May, 1914.)—Since the transport-numbers of the ions may vary with concentration, it is impossible to calculate the ionisation accurately from the conductivities in the ordinary way. Better results will be given by the formula, $\gamma = \Lambda/\Lambda_0 \cdot T \cdot \eta/\eta_0$, where T is the transport-number and η the viscosity. Direct experiments with hydriodic acid showed that the transference-number for the kation is constant at 0.826 ± 0.001 from 0.2 to 0.06N. The viscosities were 0.9954 at 0.1968N, 0.9966 at 0.0984N. The conductance was measured from 0.2 to 0.001N. The formula given above would indicate only 97 % dissociation at extreme dilution; this might be due to a change in the transport-number, but is more probably due to faults in the measurements of conductance, arising especially from doubt as to the way in which the water-correction should be made. T. M. L.

1934. *Ionisation and the Law of Mass Action. II. Osmotic Data in Relation to Combined Water*. W. R. Bousfield. (Chem. Soc., Journ. 105, pp. 600-609, March, 1914.)—The gas-equation $PV = RT$ when applied to the osmotic pressure of cane sugar at 20° gives values of R which rise by 20 % in the range of concentrations from $N/10$ to N and reach a value 87 % greater than the gas-constant. The "weight-normal" equation, which may be written $Phe/1000 = RT(h = \text{no. of mols. of water per mol. of solute, } e = \text{mol. wt. of water})$ gives values which increase only by about 6 % from 0.8 N to N , and average only 6 % above the gas-constant. If, however, only the free water be considered, the equation becomes $P(h - n)e/1000 = RT$ or $P(h - n) = R'T$; if the combined water n is assumed to be constant at 6 mols. per mol. of solute the value of R only varies 8 % between $N/2$ and N , and the mean of values, 0.0820, differs very little from the gas-constant 0.0821.

In the same way only the free water may be regarded in studying freezing-points. The equation then becomes $\Delta(h - n) = F'i$, where $i = 1$ for non-electrolytes and $F' = F/1000/e$ ($F = 1.865$ for water, $e = 18.016$). Morse and Fraser discovered the relation $\Delta = 1.85 M\rho$, where ρ is the density of the solution. If the two freezing-point equations be combined they give $n = h(1 - 1/\rho)$. The values of n calculated by this equation from the freezing-point data agree satisfactorily with those calculated from the osmotic equation $P(h - n) = R'T$ on the assumption that R' is constant and n a variable.

A similar equation is given for the lowering of the vapour pressure, which the author expresses in a later paper by the equation $\delta p/p \cdot (h - n) = i$, where $i = 1$ for non-electrolytes. The three equations may be combined in the form $P/R'T = \delta p/p = \Delta/F' = i/(h - n)$, where $F' = 108.2$ and $R' = 4.557$. T. M. L.

1935. *E.M.F. of Concentration Cells of Solutions of Sodium in Liquid Ammonia*. C. A. Kraus. (Amer. Chem. Soc., Journ. 86, pp. 864-877, May, 1914.)—From measurements of the electromotive force of concentration cells of solutions
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of sodium in liquid ammonia values have been calculated for the transference numbers at different concentrations. The ratio $(1 - n)/n$ of the fraction of the current carried by the negative and positive ions approaches a limiting value of 7 in dilute solutions, and increases to 280 at a concentration somewhat less than normal. Assuming the speed of the positive ion to remain constant, the mean speed of the negative ion increases 40 times between about 0.001 and 1.0 normal. Assuming the equivalent conductance of the positive ion to be 180 (that of the sodium ion), the equivalent conductance of the dilute metal solution is calculated to be 1040. These results are accounted for on the assumption that the ions Na^+ and e^- exist in solution. At high dilutions the negative electron e^- , which serves as negative ion, is surrounded by an envelope of ammonia which determines its speed. At higher concentrations some of the negative electrons are free from the ammonia envelope for a fraction of the time and move with a speed comparable with that of the negative electrons in metals. This accounts for the rapid increase of the transference number of the negative carrier at higher concentrations, for the number of free electrons increases as the proportion of metal to ammonia increases. The electrode phenomena already described are in accord with this hypothesis.

On the basis of the osmotic work involved, it is shown that in the most concentrated solutions a portion of the current is carried by carriers not associated with ordinary matter. T. M. L.

1936. *Potential of the Copper Electrode and Activity of Bivalent Ions.* G. N. Lewis and W. N. Lacey. (Amer. Chem. Soc., Journ. 86, pp. 804-810, May, 1914.)—The best obtainable value for the normal electrode potential of copper against cupric ion at 25° is $E^\circ = -0.8469$ volt, a figure that is probably correct within 1 millivolt. The value deduced in the ordinary way is $E^\circ = -0.8847$ volt, more than a centivolt lower. T. M. L.

1937. *Electrostenolysis.* H. N. Holmes. (Amer. Chem. Soc., Journ. 86, pp. 784-789, May, 1914.)—By electrostenolysis is meant the deposition of a metal or its oxide in very fine capillaries when the solution filling these capillaries is electrolysed. Frequently there is an evolution of gas from the deposit. Braun, who was one of the first to study this phenomenon, could only use glass capillaries: but deposits of metallic oxides and metals, due to electrostenolysis, are greatly increased by the use of capillary membranes in the form of glass tubes packed with such finely powdered substances as glass, sulphur, and silica. These tubes can be broken in sections and the contents examined very advantageously. In addition to the results obtained by Braun, electrostenolytic deposits were secured in aqueous solutions of cuprous bromide, cuprous iodide, copper sulphate, Fehling's solution, sodium plumbite, sodium stannite, ammonium molybdate, manganese chloride, and nickelous bromide. These results were secured with direct current at 110 volts, but a deposit was also secured in a solution of cobaltous bromide using alternating current. A discharge of bromide ion was observed around an initial deposit of cobalt peroxide formed by electrostenolysis. The effects are attributed to negative electrostatic charges which may accumulate till they are able to discharge the positive ions, depositing metal or oxide in the capillary. This then acts as a combined kathode and anode in the path of the current, and may grow to visible size if the current tends to deposit solid at both anode and kathode, or deposits more at the kathode than it dissolves at the anode.

T. M. L.

SCIENCE ABSTRACTS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1914.

GENERAL PHYSICS.

1938. *A Hot-shortness Testing Machine for Aluminium.* A. B. Norton. (Mech. Eng. 84. p. 840, Oct. 30, 1914. Paper read before the Amer. Inst. of Metals.)—The machine provides a simple means of measuring the strength of metals during the solidification period. It is a similar device to that used by Turner for showing expansion or contraction during solidification. A test specimen is cast in sand in such a way that as it contracts during solidification, it lifts a weight previously supported, or cracks in the attempt. Other conditions being equal, it is found that the metals which are capable of lifting the greatest weight without cracking, show the least tendency to crack in the foundry. It is found that test-pieces of Al 2 in. long and $\frac{1}{4}$ in. in diam. may raise from 25 lbs. to 225 lbs. C. O. B.

1939. *Registration of Rhythmic Hourly Time-signals.* J. Baillaud. (Comptes Rendus, 158. pp. 1780-1782, June 15, 1914.)—The reception of the Paris time-signals is usually made by two methods—coincidences or direct registration. A method is suggested for simplifying the latter method. By means of a special pendulum adjusted to beat at the same rate as the wireless signals, the phase is made to coincide with that of the signals, and then it only remains to connect the auxiliary pendulum with the chronograph. The precision obtainable is of the order of 1/500 sec. The adjustment for phase is by means of a second pendulum controlled by an electromagnet. C. P. B.

1940. *Determination of Difference of Longitude between Paris and Nice by Wireless Telegraphy.* B. Jekhowsky. (Comptes Rendus, 159. pp. 577-580, Oct. 12, 1914.)—Methods recommended by Claude, Ferrié, and Driencourt [Abstract No. 984 (1911)] have been applied to the determination of the longitude of Nice. Astronomical observations at Paris and Nice were made with the prism astrolabe. The course of the chronometers was controlled before and after the astronomical observations by pendulums. Comparisons

1942. *The Change of the Modulus of Elasticity and of other Properties of Metals with Temperature.* F. C. Lea and O. H. Crowther. (Engineering, 98. pp. 487-489, Oct. 16, 1914.)—Specimens of mild steel, micro-copper and high-tension brass have been tested mechanically at temperatures up to 700°C., in a horizontal testing machine. Heating was effected by an electrical furnace, while measurements of the elastic extensions were made by means of a specially designed extensometer. In the case of the mild steel the modulus decreases slowly from about 29.5×10^6 lbs. per sq. in. at 0°C. to about 27.5×10^6 at 800°C. Above this temperature the decrease becomes more rapid, the value of the modulus at 600° being only about 12.5×10^6 lbs. per sq. in. The ultimate stress shows a maximum at 250°, at which temperature there is a minimum in the reduction-of-area curve. When the stress obtained by dividing the breaking load by the original area is greatest, however, the stress on the actual fractured area is least. Micro-copper shows a continual and fairly constant decrease in the modulus as the temperature rises. The breaking shows a not very well marked maximum at about 150°C. An interesting point about this material is its low reduction of area at high temperatures. High-tension brass shows a continual fall in strength, and a continual rise in the ductility, with rising temperatures.

F. C. A. H. L.

1943. *Filtration of Liquids through Sand or other Similar Porous Media. Analogy between Electrical and Filtration Currents.* J. Boussinesq. (Comptes Rendus, 159. pp. 849-854, Aug. 8, 1914.)—In a former paper (Ibid. 158. p. 1846) the author has shown that the filtration of a liquid through homogeneous sand follows the same elementary law as its uniform flow through a polished capillary tube. The present paper seeks to explain this agreement, although the irregular and sinuous free spaces between the sand fragments render difficult an explanation satisfactory in every detail. Since the absolute flow velocity is very small, acceleration may be neglected, although this may itself be eliminated by rapid changes of direction, while the force due to descent will be neutralised by friction, as in the case of a polished cylindrical tube. The author's theory assumes that after a short interval there is a common direction of translatory flow movement in each small space containing a large number of sand grains, by virtue of which the pores orientated in this direction behave as cylindrical tubes filled with flowing fluid, while those pores or interstices orientated otherwise will be filled with fluid at rest, and so constitute in conjunction with the sand particles the walls of the assumed filtration tubes. On this theory the author deduces a number of interesting relations including the analogy between the filtration and electrical currents.

H. H. Ho.

1944. *Theory of the Transpiration of Gases through Porous Media.* J. Boussinesq. (Comptes Rendus, 159. pp. 890-894, Aug. 10, 1914.)—This paper is an extension of the author's theory [see preceding Abstract] on the filtration of liquids through sand, to the case of gases. The fundamental filtration formulæ established for liquids were $U = I/\mu$, $q = m/\mu I$, and $I = -d\phi/dn$, where U is the average speed of filtration, μ the specific constant characteristic of the particular medium employed, q the discharge per unit area from the surfaces of equal charge $\phi = \text{const.}$, m the ratio of the capacity of the active pores to the total apparent volume, and I is the force of descent along the normal dn at the particular level surface of charge $\phi = \text{const.}$ The particular modifications for the gaseous case are made, and,

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after a mathematical discussion, analogous formulae $U = P/p'$, $q = m/p'P$, and $P = p/L$ are established; where U , is the average speed of transpiration, q , the discharge per unit area, p' the constant characteristic of the gas and of the porous medium, p , the gas pressure at entering, and L is the length traversed. P is the quotient p/L and constitutes a kind of driving force.

H. H. Ho.

1945. *Approximate Evaluation of Filtration Constant μ for a Medium constituted of Spherical Grains of given Diameter.* J. Boussinesq. (Comptes Rendus, 159. pp. 519-525, Sept. 28, 1914.)—The present paper contains an evaluation of the filtration constant μ based upon the theory of filtration put forward in a preceding paper [see preceding Abstract]. The average speed of filtration can then be calculated for a homogeneous sand whose grains are spherical and of given diameter R . The method adopted was to divide up one of the surfaces of equal charge, supposed for example horizontal, into equilateral triangles of side $2R$ by three series of paralleled lines inclined at 60° . At each apex is placed a sphere of radius R . Then the whole volume is supposed filled with equal spheres by placing them in contact along the verticals to the first surface through the apices of the equilateral triangles. The order of magnitude of μ will remain the same with this simplified arrangement for facilitating the construction of rectilinear filtration tubes. The mathematical discussion on the above assumption is given in detail, and for water at 10° C. the result found is $\mu = 0.00062/(2R)^2$. A discussion of previous work on sand filtration with reference to the grain dimensions concludes the paper.

H. H. Ho.

1946. *Resistance of a Fluid to the Horizontal Translation of a Spindle-shaped Body in the Direction of its Axis.* Fournier. (Comptes Rendus, 159. pp. 484-486, Sept. 7, 1914.)—Experiments by Eiffel with spherical models and every other shape suitable for aeronautics, by Fuhrmann with spindle-shaped bodies of circular section, and by Costanzi on spheres and models of dirigibles, have led to an expression for the resistance R which is encountered, namely—

$$R = w/g [1 - \frac{1}{2} M (\sin \pi/2 \cdot V/\Omega)^{1/2}] \\ \times \{ K \mathcal{E} V^2 - \phi (1 - \mathcal{E}/L^2) \cos \pi/2 \cdot V/\Omega + 0.27 B V^2 (l/L)^{1/2} \\ \times [0.45 (1 + 0.44 \sin 3\pi/2 \cdot V/\Omega)]^{1/2} L^2 \}$$

in which w is the weight in kg. of 1 m.^3 of fluid, V the speed of a horizontal current in m. per sec., B the plain section of the surface \mathcal{E} of length of L and principal diam. l , ϕ the constant relative to the dynamic difference introduced by frictions, K the constant of these frictions, M a coefficient characteristic of the surface \mathcal{E} , and Ω is a critical speed whose remarkable property is to reduce R to an expression directly proportional to the square of the speed if the fluid is incompressible, and only transitorily so if it is elastic. The present author has investigated the case when the fluid is elastic and has verified his formulae from the various data to hand. [Errata (Ibid. p. 504, Sept. 14, 1914).]

H. H. Ho.

1947. *Distribution of Pressure round Cylindrical Bodies exposed to Air Currents.* A. P. Thurston. (Engineering, 93. p. 257, Aug. 21, 1914.)—A hollow rod 0.863 in. in diam., having a hole $1/50$ in. in diam. through one side, was tested in a wind tunnel; the inside of the rod was connected with one arm of a manometer, the other arm of which was connected with a Pitot

tube exposed to the same wind current. The rod was arranged to rotate so that pressure measurements at different points on its perimeter could be measured. Wind velocities were varied from 6.2 to 27.4 miles/hour, and the pressure distribution for each velocity was plotted in polar curves which show the following general characteristics:—The compression area subtends an angle of 89° on each side of the centre line. The max. suction occurs on the up-stream side of the bar about 70° from the centre line. The shapes of the curves do not appear to vary with wind velocity. The suction is uniform over the entire down-stream side. [See also Abstract No. 1777 (1918).] F. S. Cripps. (Ibid. p. 801, Sept. 4, 1914.) C. A. B.

1948. *Temperature-coefficients of the Free Surface-energy of Liquids from -80° to 1650°C .* I. *Methods and Apparatus*. F. M. Jaeger. (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 829–865, Sept. 26, 1914.)—The method of measuring surface tension by means of capillary rise cannot be used above 400° because the walls of the capillary tubes are always damaged by the action of the molten salts. The method adopted depends on measuring the max. pressure, H , in a very small gas-bubble, slowly formed at the circular, knife-edge opening of a capillary tube immersed in the liquid perpendicular to its surface, just at the moment when the gas-bubble is about to burst. To obtain the true value of H , the readings of the manometer require to be diminished by the hydrostatic pressure, corresponding to the depth of immersion i . Then if the radius of the capillary tube is r cm., the specific gravity of the liquid d , and the observed max. pressure in dynes is H , the surface-energy χ , in ergs per cm^2 , is $\chi = rH/2 - dr^2/8 - d^2r^3/2H$. The last two terms of this equation are usually so small that they can be neglected in comparison with the experimental errors. Details are given of the different forms of apparatus used to apply this method over the range from -80° to $+1650^\circ\text{C}$., and data are given for (1) water, (2) some colloidal solutions, (3) some organic liquids, and (4) some molten salts, KCl , KBr , KI , NaCl , Na_2SO_4 , Na_2MoO_4 , Li_2SO_4 , and Li_2SiO_3 . T. M. L.

1949. *Kinetic Theory of Gravitation*. C. F. Brush. (Amer. Journ. Sci. 88. pp. 118–128, Jan.–May, 1914.)—In this theory the ether is assumed to be endowed with vast intrinsic kinetic energy in wave-form of some sort capable of motive action in particles, atoms or molecules of matter, and propagated in every conceivable direction so that the wave energy is isotropic. The waves are supposed of such low frequency, or otherwise of such character, that they pass through all bodies without obstruction other than that concerned in gravitation. Distribution of the ether's energy is supposed to be uniform throughout the universe except as modified by the presence of matter. Atoms or particles are imagined to be continually buffeted in all directions by the ether waves, like particles of a precipitate suspended in turbulent water. Neighbouring particles follow very nearly parallel paths, hence no collisions occur. Each particle or atom of matter is regarded as a centre of activity due to its energy of translation initially derived from the ether. There is continual absorption and restitution of the ether's energy, normally equal in amount; but the ether is permanently robbed of as much of its energy as is represented by the mean kinetic energy of the particle or atom. The particle or atom thus has a field of influence extending in all directions, or casts a spherical energy shadow, so to speak, the depth or density of the shadow varying with the

inverse square of the distance. The energy shadow of a body of matter is the sum of the shadows of its constituent parts. The energy shadows of two gravitating bodies interblend, so that the energy-density between them is less than elsewhere, and they are pushed toward each other by the superior energy-density, or wave pressure, on the sides turned away from each other.

Some interesting secondary phenomena are suggested by this conception of the mechanism of gravitation. One of these is that two bodies falling toward each other and so deriving energy from the ether would have the space between them slightly depleted of its usual wave energy, and so they would fall together a little faster than according to the inverse square law.

E. H. B.

1950. *Solar Radiation Intensities at Mount Weather, Va.* H. H. Kimball. (Monthly Weather Rev. 42. pp. 188-141, March, 1914.)—Solar radiation has been measured at different altitudes of the sun corresponding to air masses of 2.0, 2.5, 3.0-6.0 on about 10 days in each of the three months Jan., Feb., and March, 1914, and tabulated results are given in the paper. A remarkable break in the regular value of the intensity was found in Jan. For the first part of the month intensities were in fair agreement with the corresponding values for previous years, but on the 28rd a pronounced change occurred. A high haze was observed over Mount Weather on that day at sunrise and during the morning with air mass 2.0 the radiation intensity was only 60 % of the normal. During the afternoon the atmosphere cleared and the radiation rose to 87 %. Thereafter it continued about 15 % below normal till the 29th, on which day there was a dense low haze. Throughout Feb. and March values were again normal.

Intensity records are reproduced from a Callendar horizontal recording pyrheliometer for Jan. 28 (with high haze) and for Jan. 29 (low haze). By means of the interposition of a 4-in. screen between the sun and the grids of the pyrheliometer a record was obtained for periods of 20 minutes at certain times of the day of the radiation received from the sky alone. Although the total radiation received on the 28rd at midday was less than that measured on the 29th, the sky radiation alone was greater, and more than half the loss in direct solar radiation, due presumably to scattering by the dust particles, was made up by the increased radiation from the sky.

J. S. Dr.

1951. *Observations on Ocean Temperatures in the Vicinity of Icebergs and in other parts of the Ocean.* C. W. Waidner, H. C. Dickinson and J. J. Crowe. (Bureau of Standards, Bull. 10. pp. 267-278, Feb. 20, 1914.)—This work was undertaken to obtain information on the possibility of detecting the proximity of ice from temperature records. From long experience of navigating officers the usual methods of taking temperatures in sea-water at widely separated intervals give no useful information for detecting icebergs. The experimental objective, therefore, was to obtain continuous temperature records, and, from their analysis, to ascertain whether the proximity of icebergs gives rise to definite temperature variations distinct from the accidental ones usually found in sea-water. The temperature equipment receives detailed descriptions and an elaborate set of diagrammatic records is appended. Variations in the salinity of sea-water due to dilution by ice melting are found to be so small as to be entirely masked by the accidental variations found in sea-water. The experiment of sounding the foghorn in the vicinity of a number of bergs was tried, but in no instance was an echo

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detected, while the effects of cannon fire in breaking up icebergs were disappointingly small, and the utility of powerful searchlights in their location surprisingly limited. Although the lookouts were provided with spy-glasses or with binoculars, it is of interest to note that the icebergs were invariably first seen with the unaided eye. Samples of ice broken from the berg by gunfire were found to contain considerable amounts of included air, which probably accounts for their white appearance. The ice was surprisingly hard and free from any definite cleavage planes. The temperature of the air furnished no evidence of value as to the proximity of a berg. In some parts of the ocean the water temperatures were practically constant to a few tenths of a degree for many hours, while in other parts, where no ice was near, the temperature variations were as great and as sudden as any observed in the neighbourhood of bergs. Having established the existence of such variations it follows that it will be very difficult, and often impossible, to draw definite conclusions as to the proximity of ice from temperature-records. The temperature records of Professor Barnes very generally show a temperature-rise as a berg is approached, and this is regarded by him as the "characteristic iceberg effect." The present authors' records do not corroborate this, and they explain these observational differences as due to variations in the effects due to bergs under different conditions—a conclusion supported by the fact of different temperature records being obtained in approaching a given berg along different courses.

H. H. Ho.

1952. *Capillarity in Rocks with relation to Vulcanism*. J. Johnston and L. H. Adams. (Journ. of Geology, 22. pp. 1-15, Jan.-Feb., 1914.)—The idea that many of the phenomena of vulcanism may be produced by the percolation of surface water down to the zone of highly heated magmas involves difficulties with regard to the mechanism by which the transference of liquid may take place. The old capillarity experiment of Daubree is often quoted as showing how capillarity may assist in the operation, but the experiment is here described and shown to have limitations, being nothing more than a particular application of the atmometer. It is thus shown that the magnitude of the possible effect under various conditions may be deduced from the laws of capillarity. Capillary forces are only effective when there is a surface of separation within the pores, and diminish steadily with rise of temperature, vanishing at the critical point of the liquid. Calculation shows that the effects possible at any considerable depth are, in comparison with the pressure due to the hydrostatic column, insignificant except in pores of such fineness that the amount of water which could flow through them is infinitesimal. It is concluded that the probabilities are against the idea of appreciable amounts of surface water being able to penetrate into the region of deep-seated and highly-heated rock masses.

C. P. B.

1953. *Effect of Lightning on Reinforced Concrete and Steel Dome*. C. D. Perrine. (Science, 40. pp. 518-514, Oct. 9, 1914.)—Describes in detail the circumstances under which the reinforced concrete walls and steel dome (sheathed with galvanised iron) of the Observatorio Nacional at Cordoba were struck by lightning. The storm was particularly severe and its centre not over a mile S. by SE. from the Observatory. The storm travelled S. to N. and most of the discharges were between clouds and earth. A particularly severe direct stroke struck the lightning conductor on the Observatory and then the whole surface of the metal dome appeared to be covered with sparks or flashes. The lightning rod proper extends about 1 m. above the

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highest part of the dome and terminates in a brush of heavy wire. A copper cable, attached to the track upon which the dome revolves, connects the latter and one of the vertical I-beams embedded in the concrete for grounding the circuit. No signs of any discharge were found about the dome and a peon within felt nothing when the dome was struck. A relatively small fraction of the discharge may have been taken by a wooden derrick standing near the dome; probably the six lightning conductors on neighbouring buildings and the metal windmill and water-tank tower reduced the difference of potential somewhat. Induced currents in the lighting and power circuits at the moment of discharge were heavy enough to blow fuses in each. The author concludes that this experience was a severe test for the dome and wall construction and proved its ability to carry off the discharge without the least apparent damage.

R. E. N.

1954. *Cause of Solar Heat.* A. Véronnet. (Comptes Rendus, 158, pp. 1649-1652, June 8, 1914.)—Approximate calculations are made to investigate to what extent the various theories of the maintenance of the sun's heat are supported when the factors obtained from actual observation are introduced. The three main theories regard the solar heat as kept up by (a) chemical action, (b) intra-atomic energy, (c) the work of gravitational attraction. The author finds that chemical action would only account for 2000 years of solar activity, and intra-atomic energy 170 years, both evidently quite inadequate for the known past activity. Coming then to the Helmholtz gravitational view, he finds that the energy due to contraction gives a value of several millions of years, which, being in accord with the period demanded by geological records, he accepts as being reliable.

C. P. B.

1955. *Solar Halo seen in Virginia.* A. W. Freeman. (Science, 40, pp. 595-596, Oct. 28, 1914.)—A very brilliant solar halo, and appendages, was visible over a considerable portion of East Virginia for several hours on Nov. 2, 1918. The sketch accompanying the note shows the haloes of 22° and 46° , parhelic circle, parhelia, anthelion, and a tangent arc at the upper part of either halo. The tangent arc to the halo of 22° is prolonged to nearly 800° round the horizon. Four bright spots at intervals of 90° are marked on the inner halo. The accessory "suns" were at times almost as brilliant as the sun itself. The large circles round the horizon were distinctly marked, and persisted for hours. The anthelion, or bright spot opposite the sun, was only occasionally visible. The bows were brilliantly coloured, and could be seen until the sun was almost down. The sky was nearly clear, except for a few wisps of cloud and a thin haze which was densest over the face of the sun.

A. E.

1956. *A Third-order Rainbow.* H. W. Farwell. (Science, 40, p. 595, Oct. 28, 1914.)—The observer, standing near a lake at Bridgeport, Conn., on Sept. 11, at 4.45 p.m., noticed a rainbow in an unusual position. The sun was, roughly speaking, 60° from the zenith. The sky in general was clear, though there were heavy clouds above the eastern horizon and very light cloud streaks between the observer and the sun, with a few fleecy clouds near the zenith. No rain had been falling, nor seemed likely to fall for hours; yet, between the observer and the sun, some 10° from the zenith, there appeared between two of the clouds a distinct rainbow, clearly seen by other persons. The bow was rather short, not over an eighth of a circumference, convex towards the sun, and showed plainly the usual rainbow colours.

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The observer forgot to note the order of the colours, but thinks the red was on the convex side. The rainbow is explained as "the result of three internal reflections within suspended drops of such small size and number as to give no appearance of a cloud." The angle between emergent and incident rays after three internal reflections would be about 42° , which agrees passably with the rough estimate of 50° . Various authorities state that bows corresponding to three reflections are never seen, on account of the much more intense direct light from the sun. In this instance the light clouds between the observer and the sun may have served to diminish the intensity of the direct light sufficiently to let the bow be seen.

A. E.

1957. *General Displacement of Fraunhofer Lines*. W. H. Julius. (Observatory, No. 475. pp. 252-257, June, 1914.)—In discussing the results obtained by Evershed at Kodaikanal, showing distortions of lines in the spectra of excentrically located sun-spots, and the general displacements of the Fraunhofer lines towards the red, which have been ascribed by other observers to the action of pressure or velocity, the author suggests that the phenomena are completely explained by the action of anomalous dispersion, and promises to discuss the matter fully in a paper to be published later.

C. P. B.

1958. *Displacements of Fraunhofer Lines to Violet*. T. Royds. (Kodaikanal Observatory, Bull. No. 88. Nature, 98. p. 464, July 2, 1914. Abstract.)—While the majority of the metallic lines in the solar spectrum are shifted towards the red when compared with their positions in the electric arc spectrum in the laboratory, there seem to be important exceptions. In the case of lines unsymmetrically widened, there is a difference between their behaviour in the arc and sun, as compared with lines symmetrically widened, which all show displacements to the red. Tables are given showing the details of the variations.

C. P. B.

1959. *Evidences of Rapid Convection in Stellar Atmospheres*. W. W. Campbell. (Lick Observatory, Bull. No. 257, 1914.)—Following up the view proposed by Evershed, that the displacements of the solar spectrum lines towards the red are not due to pressure but to velocity, the idea is extended to explain the anomalous radial velocities of certain stars. Thus the B stars generally exhibit velocities about 4.5 km. per sec. too great, and this may be due to violent convection currents in the atmosphere of these stars. In the highly attenuated stars with large volumes, these velocities of the atmospheric gases may be very much larger, and might conceivably give rise to the wide hazy absorption lines in many spectra of early type stars.

C. P. B.

1960. *New Hydrogen Line, $\lambda 4686$* . E. B. Frost. (Observatory, No. 475. p. 261, June, 1914.)—Measurements have been made of this line in numerous stellar spectra, the most reliable being in the spectrum of 10 Lacertæ, a fifth-magnitude star of spectral class O.5 (Harvard). From independent measures by two observers on 15 plates the resulting wave-length of the line is 4685.90 .

C. P. B.

1961. *Stars with Variable Radial Velocity*. R. E. Wilson. (Lick Observatory, Bull. No. 257, 1914.)—A list is given of five stars whose spectra show evidence of variable velocity in the line of sight, with details of magnitude, spectral class, etc.

C. P. B.

LIGHT.

1902. *Determination of Relative Refringence of Mineral Grains under the Petrographic Microscope.* F. E. Wright. (Washington Acad. Sci., Journ. 4. pp. 889-892, Aug., 1914.)—Two standard methods are in common use by microscopists for determination of the relative refractivity of two adjacent mineral grains in the thin section, and also of a single grain and the liquid in which it is immersed; the first method is based on the phenomena produced by central illumination with a narrow pencil of incident rays, while in the second the phenomena obtained by oblique illumination are observed. But in many instances it is difficult to detect the faint differences in light intensity at the margins of the grains by means of which the differences in refractivity are recognised. By introducing certain modifications, involving both the sources of light and a new method of two-fold oblique illumination, it is possible to render the phenomena more easily visible, and thus to relieve the eye-strain and also to increase the accuracy. In place of the sodium flame ordinarily used, the following sources are substituted: mercury, helium, and either a calcium flame, or a molybdenum or tin spark. With these lights set up side by side, in conjunction with a monochromatic illuminator (or dispersion prism or suitable filters), the following spectrum lines are available: 546, 560, 578, and 588 $\mu\mu$. It is not difficult to determine between which two of these four lines the refractive indices of mineral and liquid coincide. Now the index of solids increases about 0.001 for a decrease in wave-length of 10 to 20 $\mu\mu$, while for liquids the change is about twice as great. If therefore the index of a mineral be measured for any wave-length between 546 and 588, its index for 589 (D line) can be estimated with an error under 0.001, and a liquid then prepared of this index, whereupon the estimated index of the mineral grain can be checked by immersion in the new liquid. Oblique illumination is obtained ordinarily by means of a sliding stop below the condenser. To reduce the field illumination, and thus increase the differences in relative intensity, a double stop has been found useful. This device consists essentially of two safety-razor blades mounted in horizontal positions on a vertical connecting bar, which in turn is attached to the side of the stage support of the microscope. These blades are so adjusted that as the lower blade swings into position below the condenser, the upper blade is brought to rest in the conjugate image plane above the condenser and between the objective and slide. The upper knife-edge faces the edge of the image of the lower one, and when the two edges just meet, the entire field of view is almost dark. If the upper blade be gradually moved away from the edge of the image, the phenomena due to oblique illumination from the lower stop are observed at first under reduced field illumination, the illumination gradually increasing until finally the conditions of ordinary oblique illumination are reached. The edges which appeared bright in the first case are now dark, and *vice versa*. The movable upper stop not only increases the distinctness of the ordinary phenomena of oblique illumination by reducing the field illumination, but it also enables the observer to reverse the phenomena, and study the slight differences in illumination against a dark field, for which the eye is more sensitive. The principle on which the first part of the new method is based is that first used by Foucault for testing the aberrations of a telescopic lens.

A. E.

1903. *Photographic Null Method for measuring Absorption in the Ultra-violet.* W. R. Ham, R. B. Fehr, and R. E. Bitner. (Frank Inst., Journ. 178, pp. 299-328, Sept., 1914.)—The primary object of this investigation was to develop a photographic method whereby the absorption of ultra-violet light by various absorbing media could be determined quantitatively. The principle of the method adopted was as follows: The absorbing medium was placed in the path of a beam of light of constant intensity and an exposure was made for a given length of time. The medium was then removed and the intensity of the light reduced by a known amount. Another exposure was then made, for the same length of time as in the first case, on the adjacent portion of the plate. By making several exposures as above with different reduced intensities of the incident beam, a very close match could be obtained between two adjacent images of the same spectral line, and hence a fairly close estimate was obtained of the absorption for that particular wave-length. A concave grating apparatus was used in conjunction with a 220-volt quartz mercury lamp, which was found to operate with great constancy after 20 minutes. For reducing the intensity of the incident beam a set of square-woven wire screens was made up, giving a range of transmission of from 5 to 95%. The method as described gives coefficients of absorption easily to within 5%. To secure the best results the intensity of the transmitted beam of light and the time of exposure should be such as to give a light grey image on the photographic plate, and of course no shadows of the wires of the screens should appear on the grating. The time of exposure should be 10 secs. or more. In working with very faint lines the slit width should not be more than 0.8 mm. nor less than 0.2 mm. Results, with numerous photographs, are given for a number of different specimens of glass. A. W.

1904. *Relation of Absorbing Power and Polarisation.* A. Boutaric. (Le Radium, 2, pp. 74-81, March, 1914.)—Experiments were undertaken with the object of determining the relationship between the absorbing power and the polarisation of different illuminations passing through various media, such as silver chloride suspended in water, resin in alcohol, etc. The problem is related to the investigation of the transparency of the terrestrial atmosphere and the polarisation of skylight. It had previously been found that the proportion of polarised light diminishes as the absorbing power increases. [See Abstracts Nos. 1128 (1918), 407 (1914).] C. P. B.

1905. *Law of Reflection by Unpolished Substances.* B. Fessenkoff. (Comptes Rendus, 158, pp. 1271-1278, May 4, 1914.)—Formulæ are developed for the analysis of reflected and absorbed light at the surface of unpolished substances, the results giving parameters depending on the nature of the light and the properties of the substances. Calculations from the formulæ are given in comparison with the observations of Ångström on gypsum, magnesite, and magnesium carbonate, showing a very close agreement. C. P. B.

1906. *Dispersion of Ultra-violet Rays in Aqueous Saline Solutions.* K. Lübben. (Deutsch. Phys. Gesell., Verh. 16, 4, pp. 180-190, Feb. 28, 1914.)—Dispersion data are found for certain saline solutions, and the proper frequencies of the ions computed from these. The influence of dissociation on these proper frequencies is discussed, as are also changes in the frequencies, occasioned by thermal causes during solution and dissociation, computed on the basis of the quantum theory. A. D.

1967. *Dispersion of Ultra-violet Rays in Aqueous Saline Solutions.* C. Lübben. (Ann. d. Physik, 44. 7. pp. 977-1010, July 17, 1914.)—The equivalent percentage increment of refraction, $\Delta_n = 100(n - n_0)/n_0m$, depends linearly on the electrolytic degree of dissociation; $\Delta_n = \beta_n + (A_n - B_n)i$. With the aid of the linear expression the values of the increment of refraction for the ion solution $= A_n$ and for the molecular solution $= B_n$ can be extrapolated. The relative refractive index of the ion solution, $n/n_0 = 1 + (A_n/100)$, depends on the wave-length according to the simple Ketteler-Helmholtz law with a specific vibration $n^2 = 1 + a + M_n/(\lambda^2\lambda_0^2)$. The kation has no observable influence on the specific frequency of a solution; so that the specific wave-lengths for Cl, Br, I, F, ClO₃, and ClO₄ can be determined. Dissociation affects the calculated specific frequency in a manner traceable to the change in the number of molecules per unit of volume. Use is made of the quantum theory to compute the changes in the specific frequency due to solution of the salt and to dissociation. A. D.

1968. *Preventing Reversal in Photography.* R. E. Crowther. (Photographic Journ. 54. pp. 250-257; Discussion, pp. 257-260, June, 1914.)—The latent image; importance of the compound of halogen with gelatine; effect of steeping plate in a para-diamido substitution product of benzene, A. D.

1969. *Want of Uniformity in Photographic Development.* H. Seemann. (Zeitschr. wiss. Phot. 18. pp. 888-847, April, 1914.)—In stand development the result is greatly affected by streams of reduction products, which cling to the face of the film as they descend. Streaks are thus occasioned, and inequalities at the different levels of the plate. If the plates be horizontal or nearly so, face downwards, the products fall off; but no stand development can give faultless results. For landscape, however, the aberrations of density are ordinarily very small. Even with constant shaking it is impossible to avoid errors in uniformity and the production of hair-lines at boundaries of brightly illuminated areas. A. D.

1970. *Photographic Resolving Power of Plates.* P. G. Nutting. (Photographic Journ. 54. pp. 265-270, June, 1914. Communication from the Research Lab. of the Eastman Kodak Co.)—An investigation of the density gradient at the edge of an image formed by printing with a carefully prepared straight-edge. Reproduced micrographs showing the distribution of silver granules under different conditions are given. A. D.

1971. *Gradation in Photography: Measurement of Gamma.* F. F. Renwick. (Photographic Journ. 54. pp. 168-166; Discussion, pp. 166-167, April, 1914.)—Description of an improved wedge-screen instrument for gamma measurement. A. D.

1972. *Photographic Density Meters.* F. F. Renwick. (Photographic Journ. 54. pp. 167-172; Discussion, pp. 172-174, April, 1914.)—Discussion of density measurement methods, and description of an improved Ferguson bench photometer for measuring densities. A. D.

1973. *Images due to repeated Reflection within a Prism, and a New Method for determining the Angles of a Prism.* J. M. Byvoet and R. Sisingh. (Zeitschr. phys. u. chem. Unterricht, 26. pp. 81-88, 1918.)—In examining VOL. XVII.—A.—1914.

the refractive properties of a triangular prism, it is often found that, for moderate angles of incidence, three images of the collimator slit, instead of one, are seen in the telescope. One, due to external reflection at the front of the prism is a little brighter than the other two, which are evidently due to rays entering the prism and undergoing three internal reflections. Two of these internal reflections are total, which accounts for the fact that the two extra images are not much fainter than the image formed by the single external reflection, which takes place in air and is accompanied by loss of light. The author discusses the various paths which the rays may pursue inside the prism, and derives expressions for their deviation on emergence in terms of the prism angles and known quantities. These expressions enable the angles between the prism faces to be calculated with considerable accuracy from measurements of the positions of the slit images. In an example given, the prism angle is obtained to within two-tenths of a minute of arc.

A. E.

1974. *Possibility of Detecting Contractions of the Order of the Fitzgerald-Lorentz Effect.* C. Barus. (Amer. Journ. Sci. 88. pp. 852-854, Oct., 1914.)—Describes with diagrams an interferometer apparatus which it is hoped may be found capable of detecting contractions of the order of the Fitzgerald-Lorentz effect. [See Abstract No. 1179 (1914).]

E. H. B.

1975. *Photography: Simultaneous Development and Fixing.* C. Otsuki and T. Sudzuki. (Kyōtō Coll. Sci. Engin., Mem. 6. pp. 25-28, March, 1914.)—After exhaustive trials, the authors find the following to work well. Solution A, water 60 c.cm., anhydrous sodium sulphite 8 gm., metoquinone 0.6 gm.; Solution B, water 40 c.cm., hyposulphite of soda 6 gm., caustic soda 0.5 gm.: for use mix 3 volumes of A and 2 volumes of B. The difficulty to be surmounted was the want of sufficient density, with the eating away of shadow details.

A. D.

1976. *Photography: Distribution of Silver Granules in the Developed Image.* O. Tugman. (Photographic Journ. 54. pp. 270-278, June, 1914. Communication from the Research Lab. of the Eastman Kodak Co.)—An investigation of effect of light. The method employed is to cut microtome sections of exposed films and then develop; this gets rid of difficulties occasioned by the varying penetration of the developer. Microphotographs showing results are given.

A. D.

1977. *Optical Properties of Yttrium Platinocyanide.* S. Boguslawski. (Ann. d. Physik, 44. 7. pp. 1077-1105, July 17, 1914. Abridged dissertation, Göttingen.)—Yttrium platinocyanide shows some anomalies, such as the occurrence of dark patches in all the quadrants seen in polarised light, and the deformation of the curves of equal difference of path. The author shows how these can be explained on certain assumptions regarding the optical constants of feebly absorbent substances.

E. E. F.

1978. *Integration of Light from a Variable Source.* H. S. Hatfield. (Electrician, 78. p. 267, May 23, 1914.)—A proposal is made to combine the hydrogen voltameter with the photoelectric cells of Elster and Geitel, and thus provide a means of recording the variation in c.p.-hours of the intensity either of sunlight or diffused daylight. It is thought that the instrument could be made almost automatic, merely requiring reading say once a week and resetting, with possible attention to battery, etc.

C. P. B.

1979. *Fundamental Law of the Grating*. J. T. Howell. (Astrophys. Journ. 89. pp. 280-242, April, 1914.)—A description is given of an investigation of the possibility of making measurements of the highest precision with diffraction gratings by the method of coincidences. Using the international standards from $\lambda 5286$ to $\lambda 5484$ in the second order, the third-order coincidences were determined with two gratings, one having 15,000, the other 20,000 lines per inch. It was shown that, starting with one standard line, and assuming the law of gratings, it was possible to determine the values of secondary standard lines to the requisite accuracy. C. P. B.

1980. *Non-spherical Dioptric Systems*. Boulouch. (Comptes Rendus, 159. pp. 43-45, July 6, 1914.)—A theoretical study of certain cases of elliptical and ovoidal mirrors. E. E. F.

1981. *Light-quanta*. J. Ishiwara. (Sci. Reports, Tôhoku Univ., Sendai, Vol. 1. No. 2. pp. 67-104, 1912.)—A mathematical discussion of the quantum theory, which, after an introduction as to the theoretical and experimental bases, treats (i) stationary radiation in free space and in solids, and (ii) general electromagnetic and optical phenomena. [See Abstracts Nos. 1458 (1908) and 1578 (1909).] E. H. B.

1982. *Replacing Photographic Plates by Gelatino-bromide Papers in Radio-graphy*. C. H. Vaillant. (Comptes Rendus, 159. pp. 498-499, Sept. 14, 1914.)—Gelatino-bromide papers are only one-thirtieth the weight of plates, cost only one-third as much, and are not fragile. The times of exposure are less rapid than with plates, so that it becomes necessary to use a reinforcing screen. The following are some of the exposures required with the paper used :—

Hand, foot.....	4 secs.	Leg	10 secs.
Wrist	6 "	Shoulder and knee ...	15 "
Elbow, instep	8 "	Thorax	30 "

The coil used gives a 25-cm. spark. The detail of the photographs depends chiefly on the reinforcing screen employed. The developing bath which has been found to give the best results is made up as follows : Water, 1000 ; sodium sulphite (cryst.), 60 ; potassium carbonate, 60 ; hydroquinone, 15 ; potassium bromide, 1. A. E. G.

1983. *Spark Spectrum of Nickel under Moderate Pressures*. E. G. Bilham. (Roy. Soc., Phil. Trans. 214. pp. 859-871, Oct. 9, 1914.)—Solar wave-lengths are in general slightly greater than terrestrial, and this discrepancy has been attributed to the pressure of the solar reversing layer. Accordingly the effect on the nickel spark spectrum of pressures of 6 and 11 atmos., which are comparable to the pressures estimated for the solar layers, are here investigated. The pressure-chamber, method of excitation, and spectrograph employed are minutely described, together with the design and manipulating of the measuring apparatus. Burns's values for the iron arc spectrum are used as standard lines, and the measurements attain a max. accuracy of 0.002 Å.U. The region investigated lies between $\lambda 8446$ and 4598 , and the detailed measurements are supplemented by reproduction of the spectrograms. The results may be summarised as follows :—The lines exhibit a remarkable variety of behaviour and may be divided into five classes according to their types of reversal or broadening. With increase of pressure the enhanced lines decrease in intensity and broaden symmetrically, while gas lines disappear. All lines

are displaced towards the red, and the general effect on the relative intensities of the lines is similar to that of including self-induction in a spark circuit. For symmetrical and unsymmetrically reversed lines the average shifts are the same, but unreversed lines show larger shifts, and of these latter the lines which broaden unsymmetrically towards the red suffer the largest shifts. Certain abnormalities indicate the existence of enhanced lines at $\lambda 8514.14$ and 8808.98 (approx.), which almost coincide with two lines of the arc spectrum.

C. S. G.

1984. *Spectrum of the Oscillatory Discharge in Various Gases.* R. Brunetti. (N. Cimento, 7. Ser. 6. pp. 390-410, June, 1914.)—The author has investigated the spectra of the oscillatory discharge passing between magnesium electrodes in hydrogen, oxygen, nitrogen, and CO_2 . The first part of the discharge shows lines of the gas and of the metal of high and low excitation; in the second part the metallic lines of low excitation remain and are accompanied by the bands of the gas and of the compounds of the latter with the metal. The bands start from the positive electrode and cease at a distance from the negative one, whilst the gas lines traverse the whole space between the electrodes, and the metal lines are not found in the regions bordering on the electrodes. The first phase of the oscillatory discharge presents, indeed, those complex phenomena known as a spark; it opens the path by ionising the gas, carries with it occasional particles of the metal and heats the electrodes to redness, being then replaced by the second phase of the discharge, namely the arc. In the latter there is a localisation of the seat of emission of the various series of lines, the principal series originating in a stratum surrounding the accessory series emitted by the central regions. The heating of the electrodes during this second part of the discharge depends on the thermal conductivity of the surrounding medium; in hydrogen, the heating does not last so long as in nitrogen, oxygen, or CO_2 , whilst the discharge is extinguished sooner. The sudden change in potential at the electrodes falls off in the adjacent regions; for equal magnitudes of the auto-induction, the difference of potential at the electrode is greater in oxygen than in nitrogen, and is least in hydrogen. The luminous emission is subjected to the action of the gas in which the discharge takes place, since the gas modifies to some extent both the distribution of the electric field interposed between the electrodes and also the temperature of the medium.

T. H. P.

1985. *The Stark-Lo Surdo Phenomenon.* A. Garbasso. (N. Cimento, 7. Ser. 6. pp. 354-356, June, 1914.)—In his earlier work on this phenomenon [see Abstract No. 667 (1914)] the author has calculated the distance apart of the external components, parallel to the field, but he is unable to find any explanation of the internal components, normal to the field. Bohr's theory, in its present form, does not appear to lend itself to calculation of the latter phenomenon, which, contrary to the statements of Stark and Lo Surdo, does not turn on the Zeeman-effect. In very intense fields, the various lines of one and the same series are decomposed according to different laws. These intense electric fields are readily obtainable by the use of narrow tubes, as suggested by Lo Surdo, and the author describes the exact experimental conditions which he has found most suitable. With a tube 1.5 mm. in diam., a p.d. of about 8000 volts and a current of 1 milliamp., the first cathodic layer is reduced in length to about 2 mm. The mean fall is thus approximately 40,000 volts per cm., and it is shown that, immediately in front of the cathode, the field is about 80,000 volts per cm. The effect may then be observed by means of a single-prism spectroscope. In order to avoid damage to the tube

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it is necessary to cut off the current occasionally. Further, the tube may be immersed in liquid air, the low temperature being without effect on the phenomenon.

T. H. P.

1986. *Band Spectra of Carbon in Magnetic Field.* H. Deslandres and V. Burson. (Comptes Rendus, 158. pp. 1851-1857, June 22, 1914.)—Until the application of large dispersion and extra strong magnetic fields was made, it was thought that band spectra were not affected by the magnetic field. With the advent of more powerful apparatus, however, it was found that various changes were introduced into the structure of the bands [see Abstracts Nos. 1489 (1913) ; 668 (1914)]. The present paper deals with the action of a field of 20,000 gauss and upwards, and a powerful spectrograph of three prisms giving a very long spectrum. The effects are somewhat complicated, and drawings are given to illustrate the variations described. It is hoped to devise means for increasing the field still further. [See Abstract No. 2010 (1914).]

C. P. B.

1987. *Fluorescence of Gases excited by Ultra Schumann Waves.* R. W. Wood and G. A. Hemsalech. (Phil. Mag. 27. pp. 899-908, May, 1914. Phys. Zeitschr. 15. pp. 572-578, June 1, 1914.)—The experiments described are in continuation of previous work by Wood [Abstract No. 120 (1911)]. A small hole is drilled through copper and condenser-sparks are discharged against the under side, at the perforated spot. The region above the plate is photographed, and it is found that the air above the hole emits ultra-violet light, excited by radiations of some kind which come from the spark. The luminosity has the form of a narrow vertical jet and by photographing through a quartz prism a spectrum is obtained showing the so-called "water band" of the oxy-hydrogen flame and the ultra-violet bands of nitrogen. A thin fluorite plate (1 mm.) placed over the perforated spot reduces the intensity of the radiations responsible for the excitation of the water band to about 5 % of their original value. This circumstance makes it seem extremely probable that ultra-violet waves much shorter than Schumann waves are being dealt with, since the latter pass readily through fluorite. Very remarkable effects are obtained with movable and stationary gases: some gases showing a much more brilliant fluorescence when moving across the jet of rays from the spark, others responding vigorously to the excitation when quite stagnant, but showing no luminosity when in motion. In the case of air it appears as though a given mass must be acted upon by the radiations from a number of successive sparks to attain its full luminosity. This appears to be true, however, for the water bands only. For the nitrogen bands the reverse is true: they are brighter if the gas is in motion. If a current of nitrogen is directed across the spark jet, the water-band streamer is interrupted and a strong patch of luminosity appears, displaced on the spectrum. Interesting effects were obtained with CO₂, hydrogen, and iodine.

E. M.

1988. *Spectrum of X-rays obtained by means of Lamellar or Fibrous Substances.* S. Nishikawa. (Mathematico-Physical Soc., Tôkyô, Proc. 7. pp. 296-298, May, 1914.)—It was previously shown [see Abstract No. 85 (1914)] that the interference patterns, obtained when X-rays are passed through fibrous or lamellar substances, can be explained by assuming that the substances consist of a number of elementary crystals in certain definite arrangements. La de Broglie's experiments [Abstract No. 246 (1914)] the analyser of the X-rays was a crystal which was kept rotating. In the present instance the X-ray spectra were obtained by using fibrous substances which

were kept stationary. Since the fibrous substance consists of a number of elementary crystals of a definite prismatic structure and arranged parallel to the fibre (though in other respects they were quite irregularly situated), it will play the same rôle as a rotating crystal in analysing the X-rays. The spectra so far obtained by this method are, however, too faint for close examination.

A lamellar substance such as boric acid was used quite successfully as an X-ray analyser—a photograph of the spectrum of a beam of rays from an ordinary focus tube with Pt antikathode, is given. This photograph shows that the positions of the lines in the spectrum agree more or less with those of other investigators. A value is deduced for the distance between successive (001) planes of BO_2H_3 . This is found to be 8.15×10^{-8} cm. Observations were also made with a tantalum antikathode.

E. A. O.

1989. *Asymmetric Diffraction and Re-diffraction of X-radiation*. I. G. Rankin and W. F. D. Chambers. (Nature, 94. p. 116, Oct. 1, 1914.)—Further work on this subject [see Abstract No. 1841 (1914)] has shown that for any one position of the bulb and object, the angle of diffraction is constant. This angle varies, however, with the distance of the object from the source in accordance with a simple inverse sine law ($d \sin \theta = 7.5$ cm.) over a wide range, 8° to 40° and 50 to 10 cm. A survey of the hemisphere of X-rays emanating from the antikathode of an ordinary bulb, by taking diffraction images of a lead disc placed at right angles to the rays, shows that there is an "optimum" or axis of symmetry lying in the plane of the kathode rays and the normal to the antikathode; the axis of symmetry making an angle of 80° with the normal to the antikathode. Around this axis the effects are increasingly asymmetric. The positions of max. intensity, as determined both by photographic and electroscopic methods, are always found to be directed to the optimum axis. It has further been ascertained that the diffracted rays are almost entirely re-diffracted by a second edge. The re-diffraction occurs in two directions, *i.e.* within and without the shadow. Moreover, these effects are again definitely asymmetric when other than the optimum rays are used.

E. A. O.

1990. *Radium Emanation in the Atmosphere*. J. R. Wright and O. F. Smith. (Nature, 98. p. 589, July 80, 1914.)—Working in Manilla and on Mount Pauai at an altitude of 2460 m., the authors found by the charcoal method [Satterly, Abstract No. 1445 (1910)] that the average amounts of emanation present during the 8 months of observation in terms of its radium equivalent were 82×10^{-13} gm. at sea-level and 19×10^{-13} gm. (per litre ?) on the mountain. In both cases the ratio of the greatest to the least amount observed was 4 to 1, and the changes were closely related to the weather. Fair weather gave high, and heavy rain low content, especially low during typhoons. The observations are being continued.

E. M.

HEAT.

1991. *Thermal and Electrical Conductivities of some of the Rarer Metals and Alloys.* T. Barratt. (Phys. Soc., Proc. 26. pp. 847-870; Discussion, p. 871, Aug., 1914.)—The author has developed a new method of measuring the thermal conductivities of metals which has the advantage that it can be used for the rarer metals, since rods of about 1 mm. cross-section only are required. The method, which is of the stationary temperature type, offers the further advantage that it is unnecessary to measure the temperature gradient in the rod. The quantities which have to be measured in addition to the dimensions of the rod are: the heat, H , supplied at the hot end, the difference in temperature, V , between the hot end and the enclosure, and the loss of heat, h , per cm.² of the surface for unit temperature excess. It is shown that if the length of the rod is appreciable in comparison with the cross-section, the conductivity $k = H^2 / \rho q h V^2$, where ρ is the perimeter and q the area of cross-section. Experimental details and the method of working out the results are given, and it is shown that the thermal conductivity of non-metals can also be determined in the same way. In order to test the electron theory of metals for the specimens examined the electrical conductivities, K , have also been measured and the values of k/KT tabulated, T being the absolute temperature. The values tend towards a common value 2.5 although with several metals, notably tungsten, rhodium, and iridium, there are considerable discrepancies.

F. J. H.

1992. *Melting-points of some Refractory Oxides.* C. W. Kanolt. (Bureau of Standards, Bull. 10. pp. 295-313, Feb. 20, 1914.)—The Arsem vacuum furnace previously used [see Abstract No. 830B (1918)] was slightly modified, and arrangements were made to sweep out the smoke from the heated oxides which affects the optical pyrometer readings. The materials as a rule are charged into the ring space between an outer and an inner tube; some gas (hydrogen, nitrogen, etc.), is passed down the inner tube, into which the pyrometer is sighted. The tubes are made of graphite or of tungsten, the latter being moulded in graphite. The pyrometer lamps were standardised with the aid of the melting-points (determined in graphite crucibles) of: Antimony, 680°; copper-silver eutectic, 779°; silver, 960.5°; copper, 1083°; diopside, 1891° C. These observations were checked by the determination of the melting-point of platinum (1 to 8 gm., as in the case of the oxides) in tubes made of a mixture of alumina and magnesia (from the Berlin Porzellan-Manufaktur) heated in a vertical aluminium furnace; heating and cooling curves were taken as for the oxides. Magnesia does not form a carbide, but is reduced by carbon at high temperatures, especially when fused; hence cooling curves could not be obtained in the graphite crucibles mentioned. The gas used for sweeping was a mixture of nitrogen and carbon monoxide; the melting-point found, 2800° C., is much higher than the values of Hempel (2250°) and most others; Ruff observed melting above 2500°, and Greenwood used magnesia crucibles up to 2500° C. Lime was melted in a tubular tungsten crucible; the tungsten melted as soon as the lime melted, probably because it had been contaminated with carbon in the mould; hydrogen was used for sweeping; the melting-point of lime found is 2572° C. (Hempel 1900°, Ruff over 2450° C.). Alumina was melted in crucibles both

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of carbon (the carbide formation is slow) and of tungsten, in vacuum and atmospheric pressure; the resulting melting-points ranged from 2041° to 2055° , mean 2050° C. (agreeing with Saunders, whose extreme was 2100 ; Hempel 1890° , Ruff 2010° C.). Chromium oxide Cr_2O_3 was melted in graphite (slow reduction on melting) and in tungsten (into which the oxide soaked); melting-point found 1990° C., Ruff gave 2060° or 2080° C. as doubtful melting-point as there was reduction. [Author's Corrigendum: The melting-point of Pt (given as 1775°) should read 1755° .] H. B.

1993. *Convection Constants of small Platinum Wires with Applications to Hot-wire Anemometry.* L. V. King. (Roy. Soc., Phil. Trans. 24. pp. 878-482, Nov. 12, 1914. Roy. Soc., Proc. Ser. A. 90. pp. 568-570, Sept. 7, 1914. Abstract.)—The paper is divided into three portions. The first deals mathematically with the problem of the convection of heat from small cylinders in a stream of fluid. In the second part the laws of the convection of heat from small Pt-wires heated by an electric current over a wide range of temperature, air velocity and diameter are studied and the convection constants of these wires obtained; these are compared with the theoretical results. Part III is a description of a special type of portable hot-wire anemometer designed by the author and termed a "linear anemometer" in contra-distinction to the several forms of integrating instruments already described. The advantages of the new type are enumerated; these include the suitability of the instrument as a means of attacking such problems as the analysis of velocities in the neighbourhood of rapidly revolving aeroplane propeller blades, or between the blades of centrifugal fans. F. J. H.

1994. *Influence of Pressure upon Forced Thermal Convection of Platinum Wires.* A. E. Kennelly and H. S. Sanborn. (Amer. Phil. Soc., Proc. 58. pp. 55-77, Jan.-May, 1914.)—Experiments have been carried out in continuation of work already published [see Abstract No. 144B (1910)] with the object of testing the effect of air pressure upon forced convection from heated wires maintained at a constant temperature. The experimental wire was held in a fork rotated by means of an electric motor so that the wire moved in a direction perpendicular to its length. The results show that for pressures between 0.5 and 8 atmos. the rate at which heat is dissipated varies not only as the square root of the speed of the wire as already found but also approximately as the square root of the air pressure in accordance with the theoretical result of Boussinesq. Departures exceeding observational errors were found outside the above limits of pressure, which may have been caused by the production of eddy currents arising from the smallness of the tank used. The effect of moisture in the air upon the forced convection seems to be small but has not been fully investigated. It is shown that a thin vertical Pt-wire about 25 cm. long can, after being calibrated as above, serve as an anemometer. The record of wind velocity requires, however, to be corrected for both the temperature and the pressure of the air. The degree of precision is greatest at low wind-velocities. F. J. H.

1995. *Melting-points of the Refractory Elements. I. Elements of Atomic Weight from 48 to 59.* G. K. Burgess and R. G. Waltenberg. (Bureau of Standards, Bull. 10. pp. 48-59, 1914.)—The melting-points in pure hydrogen of the metals of the iron group, viz., Ni, Co, Fe, Mn, Cr, also Va and Ti are determined chiefly by means of the micropyrometer [see Abstract No. 621 (1918)] which is shown to be an instrument of precision for the determination of the melting-points of refractory metals and salts. In the cases of the

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metals examined the effect of the alloying of microscopical particles with the Pt or Ir heating strip is found to be inconsequential until after melting, the melting-points determined for Ni, Co, and Fe being the same as those found for considerable quantities heated in crucibles of magnesia in an electric furnace, the temperature of which was determined by means of a Holborn-Kurlbaum form of Morse pyrometer. For the micropyrometer determinations a calibration curve of the form $\log C = a + b \log T$ is assumed for the pyrometer lamps—where C is the heating current and T the absolute temperature—the melting-points of Ni (1452°), Pd (1549°), and Pt (1755°) being used for the calibration. In the cases of Cr, Mn, Va, strictly pure materials were not available, so that estimates for the pure substances are made from observations from the impure. The most probable melting-points of the pure metals are included in the following table—

Metal	Ni.	Co.	Fe.	Mn.	Cr.	Va.	Ti.
Purity	99.88	99.95	99.98 $\pm .01$	97.98	98.99	97.98	99.9
Probable melting-point.....	1452 ± 8	1478 ± 5	1580 ± 1	1260 ± 20	1520 to > Fe	1720 ± 80	1795 ± 15

Photomicrographs illustrating several points mentioned in the paper are given. These were taken from the cold strips after the melting-point determinations had been made.

F. J. H.

1906. *Mechanical Equivalent of Heat.* G. Guglielmo. (Accad. Lincei, Atti, 28. pp. 698–708, May 8, 1914.)—It is illogical to apply Poisson's law and the first principle of thermodynamics to the determination of the ratio of the specific heats of a gas by the method of Clément and Desormes. The author indicates a method which is free from criticism on the ground of a *petitio principii*.

E. E. F.

1907. *Inflammability of Mixtures of Methane with different Gases.* F. Leprince-Ringuet. (Comptes Rendus, 158. pp. 1999–2001, June 29, 1914.)—The experiments concern the lower and upper limits of the inflammability in mixtures of methane with oxygen, air, and carbon dioxide. When the ratio CH_4/O_2 is plotted as ordinate against the N_2/O_2 ratio (or the CO_2/O_2 ratio) as abscissa, two very similar curves are obtained, both nearly symmetrical with regard to the ordinate 0.5, the abscissæ in the latter case being 0.56 of those in the former case. Thus a mixture containing several incombustible gases behaves sensibly as if each incombustible element were replaced in a definite ratio by another of these gases. In other words, the curves are the same, but displaced in the direction of the abscissa. Hence the knowledge of one curve permits of predicting the inflammability of mixtures with other incombustible gases.

H. B.

1908. *Vapour Pressures of Silver, Gold and Bismuth Amalgams.* E. D. Eastman and J. H. Hildebrand. (Amer. Chem. Soc., Journ. 86. pp. 2020–2080, Oct., 1914.)—In continuation of the work on zinc amalgams [see Abstract No. 1554 (1913)] measurements have now been made of the vapour pressures of amalgams of Ag, Au, and Bi at about 818° . Owing to the slight solubility of silver in mercury at this temperature, only one measurement was made with an amalgam containing 1.27 % of Ag, with which Raoult's law was found to be obeyed within the limits of experimental error. Measurements

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with gold amalgams at concentrations up to 28.7 % of Au showed the separation of a solid phase at a concentration of about 16.5 %. In the more dilute amalgams the vapour pressures are greater than those calculated from Raoult's law, the assumption of a rather complex gold molecule being necessary to explain the deviations. The observed results correspond well with the equation—

$$\frac{P}{P_0} = \frac{N}{N+1} \times 10^{\frac{0.28}{(1+0.28N)^2}},$$

which is similar in form to one derived by van Laar but has empirical constants.

Bismuth amalgams of all concentrations are liquid at 818° and also give vapour pressures higher than those calculated from Raoult's law. If the validity of this law be assumed, the deviations from its simple form could be explained by assuming the two equilibria :—



this would lead to an equation containing but two constants but of complicated form. Van Laar's equation, which permits deviations from Raoult's law without the assumption of association or other chemical changes expresses the observations very accurately in the following form :—

$$\frac{P}{P_0} = \frac{N}{N+1} \times 10^{\frac{0.1495}{(1+0.284N)^2}},$$

but too much stress should not be laid on this agreement owing to the entirely empirical nature of the constants. In order to decide between the two methods of explaining the deviations from Raoult's law, recourse must be had to other means for distinguishing between normal and associated liquids.

T. H. P.

1999. Measurements of Isotherms of Hydrogen at 20° and 15.5°. P. Kohnstamm and K. W. Walstra. (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 208–216, Sept. 26, 1914.)—Unsuccessful attempts have been made to redetermine Amagat's air isotherms, since on a measuring tube being filled with air in the manner previously described [see Abstract No. 891 (1914)] and then left for some hours at high pressure (above 1500 atmos.), the mercury suffered contamination and the glass tube and Pt contacts became coated with a black deposit. Consequently measurements were made with hydrogen and detailed descriptions are given of the methods of purifying the gas, introducing the latter into the apparatus, measuring the volume, pressure, and temperature, correcting the results, etc. The pressures were measured by means of pressure balances, the values obtained being accurate to 1 in 10,000 for low pressures and to 1 in 2000 for pressures of 1200 to 2400 atmos. Tables are given showing the pressures and volumes and the values of their product, pV , at 15.5° and 20°. T. H. P.

2000. Hydrogen Isotherms of 20° C. and 15.5° C. between 1 and 2200 Atmospheres. K. W. Walstra. (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 217–224, Sept. 26, 1914.)—The results of the pressure-volume measurements of hydrogen at 20° for pressures below 1000 atmos. [see preceding Abstract] have been calculated by means of empirical equations containing four virial coefficients, $PV = a + bD + cD^2 + dD^4$, by which they can be expressed with a high degree of accuracy. For pressures of 8 to 60 atmos., Schalkwijk gave the equation $PV = 1.07258 + 0.0006671D + 0.000000998D^2$,
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and the author finds that Schalkwijk's results and those of Kohnstamm and Walstra (*loc. cit.*) are covered by the expression, $PV = 1.07258 + 0.0,6768D + 0.0,88215D^2 + 0.0,1,88954D^3 - 0.0,1,151D^4$, which represents the whole region of the isotherm below 1000 atmos. The agreement with Schalkwijk is perfect up to $D = 100$, corresponding with $P = 115$ atmos. On the other hand, extrapolation as far as ± 120 atmos. may be effected by Schalkwijk's equation, which, however, gives an error of 0.8 % at $D = 200$ or $P = 250$ atmos.; for higher densities, up to $D = 500$, the number of virial coefficients in the expression must be at least four, but it is not permissible merely to add a fourth coefficient to Schalkwijk's equation, since the deviations are sometimes positive and sometimes negative.

The data obtained at 15.5° cannot be brought into accord with those of Amagat. T. H. P.

2001. *Isothermals of Monatomic Substances and their Binary Mixtures. XVI. New Determination of the Vapour Pressures of Solid Argon down to -205° . C. A. Crommelin.* (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 275-277, Sept. 28, 1914. Communication No. 140a from the Phys. Lab., Leiden.)—Doubt having arisen as to the values previously obtained for the vapour pressure of solid argon at the lowest temperatures [see Abstract No. 272 (1914)], these measurements have been repeated and the values at -206.04° and -179.62° corrected; the temperatures were measured by means of a gold-resistance thermometer previously compared with a standard Pt-thermometer, since below -200° gold is preferable to Pt for this purpose. The extent to which the observations deviate from the Rankine-Bose formula, from Nernst's formula, $\log p_{\text{corr.}} = A/T + BT + D \log T + C$, and from the formula deduced by Sackur from Nernst's heat theorem, namely,

$$\log p = -\lambda/2.8RT + c, \log T/R - 1/2.8R \int_0^T cdT/T + C + c_p/2.8R, \text{ are shown.}$$

The heat of sublimation of argon in cal. per gm., calculated by means of the simplified Clapeyron-Clausius formula, varies from 47.86 at -189.64° to 44.51 at -206.82° . T. H. P.

2002. *Velocities of Flame in Mixtures of Methane and Air. A. Parker and A. V. Rhead.* (Chem. Soc., Journ. 105. pp. 2150-2158, Sept., 1914.)—The authors have measured the velocity of flame in a number of mixtures of methane and air in tubes of different materials. Thin strips of Wood's alloy were stretched across the middle of the tube at different points, and were fused by the passage of the flame, the exact time of fusion being indicated electrically. When mixtures of methane and air are fired from an open to a closed end of a tube, the propagation of the flame generally occurs in three distinct periods. In the first of these the flame travels with a constant and uniform velocity, whilst the second period consists of vibratory movements and a sudden increase in the velocity; in the third, corresponding with the approach of the flame to the closed end of the tube, the velocity falls to a uniform value. In tubes of a given diam. the initial velocity of explosion varies with the material of the tube, and is low with materials having a high conductivity for heat. The max. initial velocity is exhibited by a mixture containing 10 % of methane and amounts to about 70 cm. per sec. in tubes of approximately 2.6 cm. in diam. The velocity diminishes with change of the methane-content of the mixture from 10 %, and tends towards zero for 4.5 or 18.1 % of methane. The effect of a bend in the explosion tube varies considerably with the configuration of the bend and with the percentage composition of the gaseous mixture. T. H. P.

2003. *Experimental Modification of van der Waals' Equation*. J. P. Dalton. (Roy. Soc. South Africa, Trans. 4. Part 2. pp. 128-186, 1914.)—The complete table of saturation constants derived by the author from van der Waals' equation $(\pi + 8/\omega^3)(8\omega - 1) = 89 \dots (1)$ [see Abstracts Nos. 1021, 1028, and 1082 (1907)] showed that this equation gives an excellent qualitative indication of the nature of the results to be expected under given conditions, but completely fails to give reliable quantitative estimates. The author hence makes an attempt to modify the equation experimentally, and tests the modified equation against such data as are accessible. Following Kuenen ("Die Zustandsgleichung," p. 128, 1907), he regards, as a first approximation, the a of van der Waals' equation of state as a function only of T and b as independent of T . Application of well-known thermodynamic relationships to the equation $(p + a/v^2)(v - b) = RT \dots (2)$ gives $a - T da/dT = v_1 v_2 (T dp_s/dT - p_s) \dots (8)$, where p_s is the vapour pressure at temperatures T , and v_1 and v_2 are the specific volumes of the respective phases of the complex on the same isothermal. Integration between any two temperatures gives—

$$\left(\frac{a}{T}\right)_1 - \left(\frac{a}{T}\right)_2 = \int_{T_1}^{T_2} \frac{v_1 v_2}{T^2} \left(T \frac{dp_s}{dT} - p_s\right) dT \dots (4)$$

From Young's saturation data for isopentane (Phys. Soc., Proc. 18. p. 602, 1895) the integrand of (4) was calculated. The results show that $\log a$ is a linear function of T , so that $a = e^{\alpha - \beta T}$, which, with a view to the applicability of the law of corresponding states to the modified equation, may be written, $a = a_s \cdot e^{\beta T_s(1-\beta)}$. Equation (2) now takes the form—

$$\left(p + \frac{a_s \cdot e^{\beta T_s(1-\beta)}}{v^2}\right)(v - b) = RT.$$

If the law of corresponding states is to hold good, βT_s should be the same for all substances, but it probably varies more or less with the complexity of the molecule. Taking its value as unity, the last equation becomes $(\pi + 8/\omega^3 \cdot e^{1-\beta})(8\omega - 1) = 89$. This equation gives a much closer quantitative estimate of the reduced vapour pressures for isopentane and methyl alcohol than does the unmodified equation, and is in good agreement with the van der Waals empirical vapour-pressure law, $\log \pi = f(1 - 1/9)$, so long as the temperature is not too low; the value of f at the critical point, 8.04, is not far from the corresponding values for such typically normal substances as CO_2 , 2.97, and isopentane, 2.95.

The improvement effected in the author's modified equation is further rendered manifest by using the new constants for calculating the latent heat at different temperatures, the values thus obtained for isopentane showing closer concordance with the experimental figures. In his earlier work (*loc. cit.*) the author made use of van der Waals' equation to investigate the behaviour of the specific heat of saturated vapours as a function of the limiting value of the ratio of their specific heats, an attempt being made to obtain an experimental curve, for purposes of comparison, from the isopentane isothermals under a certain assumption regarding the behaviour of the specific heat at constant volume. The objection has been raised that this assumption is not in accord with the law of corresponding states, so that it has now been abandoned. The specific heats are first deduced from the modified equation, and an experimental curve is then derived from the isopentane isothermals, the Kamerlingh Onnes equation of state being used

for determining the change of C_v with the volume. Various conclusions are drawn, but the paucity of experimental data renders it impossible to test their quantitative value.

T. H. P.

2004. *New Relation between the Critical Quantities : Unity of all Substances in their Thermal Behaviour.* J. J. van Laar. (Konink. Akad. Wetensch. Amsterdam, Proc. 17. pp. 451-465, Sept. 26, 1914.)—The author brings his discussion of this subject to an end [compare Abstracts Nos. 1284 and 1558 (1914)], the principal conclusions arrived at being as follows : Within a wide range, the magnitude a of the van der Waals equation of state appears not to depend on the density, so that the molecular attraction may be represented by a/v^2 , for both the gaseous and the liquid condition. The independence or the reverse of a on the temperature cannot yet be decided. The magnitude b depends on both v and T , its dependence on v being expressed by $[(b - b_0)/(b_r - b_0)]^n = 1 - (x/x_0)^n$, where $x = (b - b_0)/(v - v_0)$ and n depends on γ which is related to $b_r : b_0$. From this it would seem that possibly the variability of b is mainly a real change, caused by the pressure $p + a/v^2$ and the temperature acting in a manner analogous to that which van der Waals had in mind when drawing up his "equation of state of the molecule," which closely resembles the above expression. Further, this agreement is remarkable with regard to the dependence on the temperature, expressed by $(b_r - b_0)/b_0 = 2\gamma - 1 = 0.04 \sqrt{T}$. But, whereas van der Waals' two exponents n are different, the author's two exponents are the same and dependent on γ , that is, on T , so that n may vary from 8.2 (for $\gamma = 1$) to ∞ (for $\gamma = 0.5$, i.e. $T = 0$). The change in b need not be attributed to quasi-association, since it can be well explained as the result of other influences. The fact that b_r gradually decreases with fall of temperature, so that it would coincide with b_0 at $T = 0$ and the variability of b would have quite disappeared—in consequence of which the ideal equation of state with constant b is the more nearly approached with the absolute zero—points to the invalidity of the kinetic assumption that for a very large volume (b_r refers only to large volumes), i.e. in the ideal gaseous state, b_r would equal $4b_0$. For, as deduced kinetically, b_r would still be equal to $4b_0$ at the lowest temperatures, whereas the author shows that b_r approaches more and more closely to b_0 at low temperatures. The reason of the inaccuracy of the earlier kinetic assumption, that $b_r = 4m$, will be referred to in a subsequent paper.

It seems that, in principle, the whole thermal behaviour of a substance does not depend solely on the two magnitudes a and b , which determine the critical quantities, the latter in their turn governing the law of corresponding states. Every substance passes through the different types characterised by the variable ratio $b_r : b_0$ —from the type of the "ordinary" substances where $b_r : b_0 =$ about 1.8 ($\gamma = 0.9$) to that of the "ideal" substances where $b_r = b_0$ ($\gamma = 0.5$)—in the descent from ordinary temperatures to the absolute zero. The individuality of different substances, which they maintain also within the region of the law of corresponding states, is therefore determined entirely by the real height of the absolute temperature. Thus, at 828° abs. ($T = 10T_A$), hydrogen will exhibit, on the whole, the same behaviour as helium at 52° abs. ($T = 10T_A$), but the former has a value of about 1.7 for the ratio $b_r : b_0$ and the latter a value of about 1.2 at these corresponding temperatures. For $v_A : b_A$, the value is about 2.7 for hydrogen and helium at their critical temperatures, whilst the value of this ratio for an ordinary substance is 2.1.

T. H. P.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

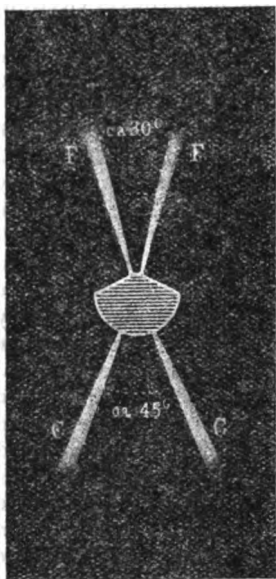
2005. *Electron Theory of Moving Bodies*. J. Ishiwara. (Sci. Reports, Tôhoku Univ., Sendai, 8. 2. pp. 65-100, March, 1914.)—A treatise on this subject which is developed from the basis of : (1) The properties of electrons and the electronic constitution of matter ; (2) the field of the electron ; (3) the principle of least action ; and (4) the principle of relativity. [See Abstract No. 1572 (1914).] E. H. B.

2006. *Atmospheric Electricity Observations made at Kew Observatory*. G. Dobson. (Phys. Soc., Proc. 26. pp. 884-846 ; Discussion, p. 846, Aug., 1914.)—The paper gives an account of some observations on the conductivity made with the Ebert apparatus and with that devised by C. T. R. Wilson. The latter is designed to measure the current which flows into a small test-plate exposed to the earth's field and kept at zero potential. The potential gradient above the test-plate can also be determined by measurement of the charge induced upon it when freely exposed, and thus the conductivity may be deduced. With the Ebert apparatus measurements can be made of the conductivity due to positive ions, λ_+ , and of that due to negative ions, λ_- . Thus the total conductivity $\lambda (= \lambda_+ + \lambda_-)$ may be obtained. Some question has been raised as to whether the conductivity as deduced from the Wilson readings is most closely allied to λ_+ or to λ , and the experiments here recorded were carried out largely to determine this question. Wilson's apparatus is commonly used on a stand with the test-plate raised some feet above the ground, and comparative readings were first taken with the instrument (a) in this position, and (b) connected to a large test-plate at ground-level. These measurements showed the conductivity as determined by the ground-level plate to be 20 per cent. higher than that determined by the ordinary method. This difference was found not to be due to any difference in the number of ions at the two levels. Evidence is put forward to show that it must rather be regarded as instrumental, the upper-level reading being adversely affected by the smallness of the test-plate and the raised position. Finally the correct or ground-level reading from the Wilson apparatus is found to agree more closely with the total conductivity of the Ebert than with λ_+ alone. J. S. Di.

DISCHARGE AND OSCILLATIONS.

2007. *Canal Rays*. E. Goldstein. (Deutsch. Phys. Gesell., Verh. 16. 11. pp. 545-566, June 15, 1914.)—The author drew attention to certain types of canal rays that are obtained with kathodes of special construction, e.g. with a triangular kathode there are 3 bundles of canal rays from the middle points of the sides [Abstract No. 2252 (1902)]. These rays start from one side and cut across the plane of the kathode before emerging into the gas space, or they commence their course by going inwards. In the present paper it is shown that there are bundles of rays which commence by going outwards. These rays can be made bright by using a double kathode, one plate being behind the other. These latter rays are named F rays, the former C rays. When circular kathodes are used, naturally there is a uniform aureole round

them. When part of the kathode is cut away in the form of a segment an F bundle is obtained from the centre of the chord going in a radial direction. A C bundle appears from the circular edge diametrically opposite, being in alignment with the F bundle. If segments are cut away on two or more chords, one F and one C bundle is obtained for each chord, the alignment still being preserved. This alignment is, however, not an essential, for if two chords intersect so that the segments cut away have a common part, the corresponding F and C bundles are not in line (see Fig.). If a dent is made in



the edge of the circular electrode, this dent having a circular outline, an F bundle emerges radially from it, and a C bundle diametrically opposite. For a number of such dents, one F and one C bundle is obtained for each. The symmetrical nature of the dent is even not necessary, for if the dents are made in the form of slits the F bundles are still radial and in line with the corresponding C bundles. So it would seem that it is the chord of the slit or dent which accounts for the F bundle. This conclusion is shown to be unsound, for if a small hole of any shape is made in the electrode near the edge, F and C bundles are still obtained and still in alignment. Further proof that alignment is not a general case is given by the use of elliptical kathodes with various kinds of dents and slits. It is next proved that the C bundles, or those going inwards over the kathode, are necessary for the production of the F bundles. This is done by surrounding the kathode by a metal band at places where the C bundles ought to emerge, when the F bundles vanish. The following explanation of the F bundle is given: The

rays which proceed inwards over the kathode ionise the space between the two plates. The positive ions are then set in motion by the electric field. When the form of the kathode is such that the rays proceeding inwards converge in a focus there will be a large ionisation at this point, and from it a bright bundle of F rays can emerge. If the kathode is circular, naturally these F rays will emerge from the whole perimeter. When some part of the circumference is nearer the focus than others, the rays will all emerge from this part, the reason for this being that the gas space near a kathode, and especially that between a double kathode, is positively charged, and the line of least resistance for the F bundle is that of shortest length.

J. R.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2008. *Thermoelectric Measurements, especially for Calorimetry.* W. P. White. (Amer. Chem. Soc., Journ. 86. pp. 1856-1868, and pp. 1868-1885, Sept., 1914.)—These two papers describe a type of auxiliary installation for thermo-elements, suitable for high-temperature measurement and other work of moderate precision, and also capable of the very high precision often desired for calorimetry. With a thermo-element having nearly the same

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temperature at its two ends the *relative* precision required in the electrical measurement falls to a value no greater than that desired in the temperature reading, and the most serious errors ordinarily affecting the electrical thermometer practically disappear. The *absolute* electrical precision required is also comparatively low. With a convenient and easily made copper-constantan multiple thermo-element of 24 couples 0.0001 deg. corresponds to 0.1 microvolt. Two special electrical instruments are required for the attainment of a precision of 0.1 microvolt: first, an arrangement for eliminating the effect of parasitic thermal e.m.f.'s for which a common copper knife switch will serve; secondly, a potentiometer reliable to 0.1 microvolt. *Split-circuit* potentiometers are satisfactory, and also *combination* potentiometers which have two otherwise separate very simple instruments in series in the same galvanometer circuit. The potentiometer system is especially suitable for simultaneous measurements of different and differently varying e.m.f.'s. The power to take the last two figures of any reading directly from the galvanometer can be easily obtained with the thermo-element-potentiometer system, and its use is often desirable for high-temperature measurements.

J. J. S.

2009. Rheostat for Large Currents. R. G. Van Name. (Amer. Journ. Sci. 88. pp. 849-851, Oct., 1914. Electrician, 74. p. 289, Dec. 4, 1914.)—This variable resistance, capable of carrying 100 amps. or more, consists of a graphite plate $\frac{1}{2}$ in. thick, having a radial piece about 2 in. wide, from which extends a curved portion forming about three-quarters of the circumference of a circle 6 in. in diam. and $\frac{1}{4}$ in. wide. The circumferential part dips in mercury contained in a copper trough. By rotation of the graphite plate about its central axis, the current has to pass through more or less of the long thin circumferential portion or through the short broad radial portion only. The whole may be kept cool by a stream of water.

E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

2010. Intense Magnetic Field. H. Deslandres and A. Perot. (Comptes Rendus, 159. pp. 488-448, Aug. 24, 1914.)—Two additional forms of electromagnet are described, in which the field is obtained chiefly by means of a very large current circulating round an insulated strip of high-conductivity metal cooled by a liquid [see Abstracts Nos. 752 and 1186 (1914)]. For several reasons, water was substituted for cooled petroleum as a cooling agent, and silver ribbon for copper. The second of these new forms of apparatus gave a field of 49,900 gauss with a current of 5000 amps. (840 kw.), no iron being employed. The first form gave a field of 48,600 gauss with 6000 amps. (570 kw.); with an iron core and a current of 5000 amps. the field obtained was 68,700 gauss. Diagrams of the two new forms are given.

G. E. A.

2011. Lunar Diurnal Variation of the Earth's Magnetism at Pavlovsk and Pola. S. Chapman. (Roy. Soc., Phil. Trans. 214. pp. 295-317, Sept. 26, 1914.)—The present paper contains an account of the methods and results of an investigation into the lunar diurnal magnetic variations at the observatories of Pavlovsk and Pola (1897-1908), and is part of a larger undertaking by which it is hoped to obtain the necessary data for the discussion of the lunar diurnal magnetic variations over the whole earth, using the method of the Gaussian potential in a manner similar to that in which Schuster applied it to the solar diurnal magnetic variations. The reduction of the observations to the

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required form is too great a labour for a single person to undertake, and the author hopes that directors of magnetic observatories will carry out the reductions for their own stations. For this purpose he has indicated what appears to be the simplest and most suitable computation method for the purpose, and also some of the lines along which the discussion of the results from a single observatory should proceed. For a general review of the subject see the author's previous paper [Abstract No. 850 (1914)].

The magnetic elements undergo regular variations with the period of a lunar day as in the course of a solar day, although the latter variations are much the larger. The lunar diurnal changes are the simpler in character, taking the form, when averaged over a whole lunation, of a purely semi-diurnal wave. If, however, the variation is computed from a number of days all at the same lunar phase (*i.e.* when there is a definite angular distance between the sun and moon), the solar diurnal variation having first been eliminated from the observations, harmonic components of other frequencies in the lunar day are found to be present. The investigation of these suggests a solar action modifying a regular semi-diurnal lunar variation. This action has been given in terms of a particular theory, *viz.*, as due to a variation, periodic in a solar day, of the electrical conductivity of the medium in which flow the currents to whose magnetic potential is attributed the variable field put in evidence by the observations. The dependence of the electrical conductivity upon solar time is accounted for on the assumption that all or part of this conductivity is due to some ionising influence from the sun, and fits in naturally with a view that the lunar magnetic variations arise from the lunar tide in the earth's atmosphere in the same way as, according to Schuster's well-known theory, the solar diurnal magnetic changes arise from the ordinary daily atmospheric motions which are indicated by the barometer. The period 1897-1908 comprises 7 years during the sun-spot minimum immediately preceding the present one, *i.e.* a period of magnetically "quiet" years, and was chosen to minimise the irregular deviations of the magnetic needle which have to be averaged out in determining the lunar diurnal variations. Pavlovsk and Pola were selected because they each publish hourly values of the magnetic elements, and their latitudes render them suitable for the main purpose of this work. The chief point of novelty and importance in the present investigation lies in the use of the harmonic components of the lunar magnetic variation of frequencies other than 2, as well as the main semi-diurnal component. The second harmonic is generally the greatest, though the first (which comes usually next in magnitude) sometimes equals or even exceeds it. The fourth harmonic is generally the smallest of all. The first three are as a rule much greater in summer than in the other seasons, but a remarkable feature is that the fourth harmonic is always greatest at the equinoxes. The fact that the fourth harmonic is appreciable at all, indicates that the diurnal variation in the atmospheric electrical conductivity cannot be represented by a simple diurnal wave $a + b \cos t$, but that terms of higher frequency in the solar day must be present.

Numerous tables and calculations are included in the paper. H. H. Ho.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2012. *Ordinals of the Elements*. J. R. Rydberg. (Phil. Mag. 23. pp. 144-149, July, 1914.)—Moseley having discovered a simple relation between some of the lines of high-frequency spectra and the ordinals of the elements (He = 2, Al = 15, Cl = 17, etc.), the author has calculated Moseley's series of lines more completely and in a somewhat different way. He uses the formula $10^8/\lambda = \nu = 109675a^2(N - C)^2$, where the ordinal number N varies by one unit from one element to the next. In all six series the values of $N - C$ (and consequently C) approach very closely to whole or half units. Assuming them to end in .0 or .5, the spectrum lines are recalculated. There is a good agreement as regards the L-lines. The author calculates the constants c and a or b of the series by taking the best values of the most constant parts.

E. E. F.

2013. *Atomic Weight of Copper by Electrolysis*. A. G. Shrimpton. (Phys. Soc., Proc. 26. pp. 292-312; Discussion, pp. 312-318, Aug., 1914.)—In order to determine the atomic weight of copper, the relative quantities of Cu and Ag deposited by the same current have been measured. Four copper cells, separating two silver cells, were run in series, the areas of the Cu kathodes varying from 10 to 50 cm.². By plotting the actual weights of the deposits against the corresponding kathode surfaces and extrapolating to zero kathode surface the effect of cathodic dissolution was eliminated, the weight of the deposit thus being corrected for under experimental conditions. Cylindrical cells with stationary and rotating kathodes were used. For the production of a uniform coherent deposit of pure metal it was found necessary to keep the cathodic current density below a certain limiting value. This value was determined in a series of preliminary experiments, and was found to depend on the form of the electrolytic cell, the concentration of the electrolyte, the presence of acid and other impurities, the presence or absence of a porous pot, and in the case of a rotating kathode on the speed of rotation. To prevent the formation of loose crystalline clusters it was also found necessary to regulate the current density according to the weight of the metal to be deposited. Empirical formulæ are given from which the limiting current density can be calculated.

The mean atomic weight for ten determinations was 63.563 ± 0.008 , silver being taken as 107.88.

T. S. P.

2014. *Determination of Molecular Weights of Small Quantities of Gas or Vapour*. M. Knudsen. (Ann. d. Physik, 44. 4. pp. 525-586, June 4, 1914.)—Experiments are described which show that the molecular weight of a minute quantity of gas or vapour can be determined from its velocity of flow through a small aperture. In the case of air and oxygen the ratio was 1.057; the square of this ratio (= 1.117) agreed within 1 % with the ratio 1.105 of the densities.

T. M. L.

2015. *Properties of the Alkali Metals*. L. Hackspill. (Ann. Chim. Phys. 28. Ser. 8. pp. 618-666, 1918.)—The alkali metals rubidium, caesium, and even potassium, can easily and rapidly be reduced in the pure state with almost theoretical yield by heating a mixture of the anhydrous chloride with metallic

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calcium in an exhausted tube of iron placed within an electric furnace. The author applies this method and determines the physical properties of the alkali metals, including sodium; he studies also the action of the metals on water. Taking the metals in the order of their atomic weights Na, K, Rb, Cs, the densities found at 0° were: 0.9723, 0.859, 1.525, 1.908; the coefficients of expansion of the solid metals: 0.000216, 0.00025, 0.00027, 0.00029 of the fused metals: 0.000274, 0.000288, 0.000388, 0.000845; the volume increases on fusion, in per cent.: 1.50, 2.42, 2.28, 2.82; the critical temperatures calculated from these latter data: 2025°, 1965°, 1857°, 1627° C. The thermal expansion was partly determined in benzene; but caesium attacked benzene under formation—without visible generation of hydrogen—of a black substance C_6H_5Cs , which takes fire on exposure to air and explodes with CO_2 ; with chloroform it reacts violently, but carbon tetrachloride and pentane have no action. The vapour-pressure curves taken between 250° and 400° show that the vapour pressure increases at all temperatures in the order stated; the vapours seem to be monatomic, but the determinations of the density of the saturated vapours were not very concordant. The electric conductivity was measured against mercury on a double bridge, the metal being sealed into a cylinder of thin glass, 200 mm. long, from 8 to 12 mm. in diam.; four Pt-electrodes penetrated through the glass into the metal. According to E. Wagner (Ann. d. Physik, 88. p. 1484, 1910) the ratio of the conductivity of the solid metal to that of the liquid metal at its melting-point should be 8:2 for metals of the alkali group; the values found were: Na, 1.6; K, 1.5; Rb, 1.5; Cs, 1.7. All the resistances observed at temperatures from the melting-point down to the temperature of liquid air were lower than those of Juritz and Broniewski—this holds particularly for rubidium. The intensity of the action of water on the metals increased with the atomic weight of the metals and ceased at the following minimum temperatures of the metals in the order stated: -98°, -105°, -108°, and -116° C. H. B.

2016. *Rotatory Power of Tartaric Acid*. G. Bruhat. (Faraday Soc., Trans. 10. pp. 84-90, Aug., 1914. From the French.)—It is found impossible to account for the anomalous rotatory dispersion of tartaric acid either by the selective absorption of the acid for the violet or the ultra-violet or by the influence of the molecules of the solvent interposed between the active molecules. It is therefore assumed that there exist in solutions of tartaric acid two active compounds endowed with rotations of opposite signs and with different rotatory dispersions, the relative proportions of the two depending on the nature of the solvent, the concentration, and the temperature. Darbois has similarly explained the variability of the rotatory power of oils of turpentine and the anomalous rotatory dispersion shown by certain of these oils; the dispersion curves for mixtures of the two pinenes are, indeed, entirely analogous to those found for solutions of tartaric acid.

The author has extended Biot's study of the rotatory dispersions of transparent masses of superfused tartaric acid, precise measurements being made at temperatures ranging from 180-185° to 15°. The results show that the cause of the anomalous dispersion and its variation, both with the concentration and with the temperature, is the same in the case of solutions of tartaric acid as in that of the pure acid. The hypothesis of the formation of hydrates must, therefore, be rejected, and it seems that the second compound existing in the solutions or in the superfused mass can only be a complex formed by the grouping together of several molecules of the acid. Consideration of the results of osmotic and cryoscopic measurements on solutions of tartaric acid

indicates that, in 25 % aqueous solutions or 2 % acetic acid solutions—which present marked anomaly in the rotatory dispersion, with a max. rotation in the blue or violet—the proportion of polymerised tartaric acid is very small and does not exceed 2–8 %. If this figure is accepted, the rotatory power of the complex will vary from about -80° to -200° between the C and F lines.

T. H. P.

2017. High-temperature Research. I. Refractory Oxides in the Electron Vacuum Furnace. O. Ruff, H. Seiferheld, and J. Suda. (*Zeitschr. anorg. Chem.* 82. pp. 878–400, 1918.)—The researches of 1910 have been resumed with the aid of a grant from the Verein Deutscher Ingenieure for the special object of finding oxides suitable as melting-point standards in electric carbon-tube furnaces. Even at considerably reduced pressure CO, H, at higher temperature further CN and hydrocarbons are generated in such furnaces, and these gases, though present in very small quantity, are capable of reacting chemically. The furnace walls adsorb air and moisture and replenish the gases. The gas pressure and the atmosphere are important; thus lime will not melt under very low pressure at 2450° , but melts at 2000° already in nitrogen at atmospheric pressure. The oxides are applied in cones, 1.5 cm. diam. 1 cm. high, or cylinders, 8 cm. high, placed on a layer of compressed carbon or graphite; the solid carbon does not appear to react with the oxide so long as there is no fusion of the oxide, which may, however, be started by a small impurity. Such reactions may cause the Leidenfrost phenomenon (oxides of Al, Mg, Ca) or reduction of the oxide; hence the carbon layer was sometimes replaced by a plate of dioxide of zirconium or magnesium, wetted and compressed. Temperature determinations were made with the aid of the Wanner pyrometer and based on the assumption, that the constant $C_2 = 14,600$, and the melting-point of Pt 1756° . The only oxide which is not reduced at ordinary pressure is magnesia, melting-point, above 2500° ; but as it reacts with carbon, it is unsuitable for standardisation. At pressures below 80 mm. the oxides of beryllium (glucinum, melting-point 2525°) and calcium are also stable, but both volatilise. Zirconium dioxide, ZrO_2 , has the highest observed melting-point, 2585° , but is partly converted into lower oxide. All these substances also make refractory vessels. Only alumina, Al_2O_3 , melting-point $2010^\circ \pm 10^\circ$ is recommendable for standardisation. The rare earths are unsuitable because they form carbides; the melting-points are: oxide of cerium, 1980° ; thorium, about 2400° ; niobium, Nb_2O_5 (not free from tantalum pentoxide), 1520° ; lanthanum, 1840° . Titanium oxide, TiO_2 , is reduced by the gases and turns, above 1000° , into the bluish oxide Ti_2O_3 ; slowly heated it begins to melt at 1800° , rapidly heated rutile at 1600° or 1700° only. Stannic oxide melts at 1625° and is at once reduced; the melting-point of Cr_2O_3 could not be determined.

H. B.

2018. Synthesis of Borides in the Electric Vacuum Furnace. E. Wedekind. (*Ber. Deutsch. Chem. Gesell.* 46. pp. 1198–1207, 1918.)—Mixtures of finely-powdered boron and the metal are highly compressed in the hydraulic press of L. Weiss, and the electrodes thus obtained are fritted and used in the arc-furnace of L. Weiss modified by the author. With currents of 40 to 80 amps. at 70 to 80 volts borides are formed which melt and drop off or are deposited as powders on the asbestos tube sheathing the electrodes. In conjunction with C. Horst, O. Jochem, M. v. Wrangell, and H. Baumhauer the author thus prepares borides of zirconium Zr_3B_4 , vanadium

VB, uranium UB₃, molybdenum, and tungsten WB₃. Most of these borides are hard (7) and resist acids and alkalis. In the case of Mo considerable difficulty was experienced, as the product would not drop off; the formula seemed rather to be Mo₃B than Mo₂B₃, the formula given by Tucker and Moody who described some of these borides in 1902. H. B.

2019. Preparation of Pure Uranium. A. Roderburg. (*Zeitschr. anorg. Chem.* 81. pp. 122-129, 1918.)—In spite of many experiments, uranium has not yet been obtained in the pure state. The author started from uranium tetrachloride and tetrafluoride. The tetrachloride is prepared by heating the ground oxide U₃O₈ with sugar to redness and then passing chlorine over the product in a porcelain boat, from which the chloride always takes up Si and Al, however. The brown metal obtained by using sodium as reducing agent in an iron vessel contains iron; vessels of nickel, silver, magnesia, and graphite are also attacked, nickel steel less so. The reduction of the tetrachloride which is more easily purified has to be effected by means of potassium, because the sodium fluoride cannot be washed out subsequently; but a suitable vessel which will prevent the escape of potassium vapours has not yet been found. H. B.

2020. Optical Orientation of Cast Metals. K. Endell and H. Hanemann. (*Zeitschr. anorg. Chem.* 88. pp. 267-274, Nov. 4, 1918.)—Some cast metals may be examined by the method of J. Königsberger by reflecting polarised light from the polished surface through a quartz plate and analyser. Two apparatus are used for this purpose; they may be attached to a large microscope; the manipulation of the apparatus is explained. Anisotropy is easily detected, and the method admits of distinguishing between enclosures in iron, e.g. Zn, Sb, Bi crystallise hexagonal-rhombohedral like ice, Sn (at least when normally cooled) tetragonal. The former crystals are orientated at right angles to the cooling surface; when the cooling metal is stirred, the orientation is irregular. Cementite Fe₃C in steel is anisotropic; so are iron phosphide and silicide, ferromanganese of 80 per cent., and sulphide enclosures, whilst silicate slag enclosures are isotropic and hence at once distinguishable. Cold-worked steel does not show anisotropy. H. B.

2021. Zirconium. II. E. Wedekind. (*Liebigs Annal. d. Chemie*, 895. pp. 149-194, 1918.)—The author, in conjunction with H. Kuzel and also S. J. Lewis, finds that zirconium oxide cannot be reduced by Al or by Mg [see end of this Abstract], but can be reduced by mixing the oxide with very fine calcium shavings in an iron tube and heating until the reaction commences, the pressure being diminished to 0.5 or 0.1 mm. of mercury. The cold product is washed, under exclusion of air, with water, acetic acid, hydrochloric acid, acetone and dried, finally at 800° to 1000° in a vacuum, when it sinters to lumps which assume a brilliant mirror polish and contain 99.09 % of Zr and some oxygen. The attempt to remove the traces of oxygen by further heating with calcium in a nickel tube failed, the resulting metal containing only 97.5 % of Zr. The purer metal, pressed into rods and fused in a furnace of L. Weiss and E. Neumann, yielded globules of 98.5 %, less pure than those obtained by the just-mentioned investigators [see Abstract No. 1526 (1910)] The melting-point of zirconium which Wedekind and W. von Bolton had previously believed to be 2850°, lies probably very much lower, near 1850°, as Burgess found in 1908. The hydride ZrH₂—in which Zr would be divalent—and the nitride Zr₃N₂ do exist; the latter is a glistening powder of tombac colour, much more stable than the Zr itself, and conducts the current when VOL. XVII.—A.—1914.

compressed. The so-called crystalline Zr is really an aluminium zirconide ; the graphitic Zr of Troost (said to be reduced with the aid of iron) is very doubtful. The amorphous Zr seems to be the only colloidal modification of the metal ; by treatment with acids it passes into a hydrosol coagulating to a gel, the black amorphous Zr of Berzelius, which is, however, not an individual substance. Both the metallic and the amorphous Zr conduct the current after heating to 1000° in a vacuum ; in air they burn ; dilute acids do not attack them, chlorine does. Finally the author and J. Teletow state that the reduction of zirconium oxide by Mg succeeds to a certain extent at high temperature in a hydrogen atmosphere ; but the repetition of the process yields a more and more pyrophoric substance, from which any oxide of the formula ZrO cannot be isolated. With the aid of calcium, the oxides of titanium, thorium, uranium, vanadium, tantalum can also be reduced. H. B.

2022. Alloys of Molybdenum and Cobalt. U. Raydt and G. Tammann. (Zeitschr. anorg. Chem. 88. pp. 246-252, Nov. 4, 1918.)—Cobalt cubes are purified by repeated fusing with broken porcelain in magnesia tubes, until a Co of 98 %, melting-point 1480° , is obtained. This is heated in magnesia tubes to 1800° ; molybdenum (reduced after Biltz by Al from trioxide) is added. Up to 65 % Mo is dissolved by the Co. The freezing-point curve shows a eutectic point at 1885° , the eutectic containing 88 % of Mo. The curve then rises up to a break at 1484° corresponding to the compound $MoCo$ which crystallises in long needles and does not form solid solutions ; it is not magnetic. The solid solutions rich in Co are magnetic, and the transformation temperature falls from 1884° for Co to $750-790^{\circ}$ for the saturated solution of 40 % of Co. There are no other definite compounds, but richer Mo alloys—impure with Al, however—can be prepared by the aluminothermic process. H. B.

2023. Ternary Alloys of Zinc-Silver-Lead. B. Bogitch. (Comptes Rendus, 159. pp. 178-180, July 18, 1914.)—Earlier researches have shown that zinc and silver form six series of solid solutions and the compound Zn_3Ag_2 ; that silver and lead form a single eutectic containing 4 % Ag ; and that zinc and lead are only partially miscible, forming two layers on cooling. The author has prepared about a score of the ternary alloys, of widely varying composition, and has studied the distribution of the three metals between the two layers. The results are plotted in the form of the well-known triangular diagram which shows that there are two fields : one, in which the three metals do not segregate from each other, and the other and larger field, in which the formation of two layers takes place. F. C. A. H. L.

2024. Structure and Properties of Iron-Zinc Alloys. U. Raydt and G. Tammann. (Zeitschr. anorg. Chem. 88. pp. 257-266, Nov. 4, 1918.)—By fusing together iron and zinc under pressure of 180 atmos. maximum the authors prepare a whole series of alloys, whilst so far 24 % of Fe had been the maximum attained ; zinc dropped into liquid iron is rejected with explosive energy. A bomb and a furnace are used. The bomb forms a cylinder, 98 mm. high, 65 mm. in diam., built up of iron and carbon ; the parts fit and are screwed into one another and are directly heated by the current. Hydrogen is admitted under pressure. The furnace is a magnesia cylinder, 60 mm. wide, surrounded by carbon rods 8 mm. in diam., which are so clamped by iron plates that the carbons appear to be bent back on themselves several times ; this furnace only stood two meltings, the zinc vapours attacking the iron-zinc contacts. The iron and zinc are placed in tubes of a special porcelain. The fused alloys are analysed and examined micro-

scopically; freezing-point curves of the iron-rich alloys have not been determined. Only two definite compounds FeZn_7 and FeZn_3 appear to exist. There is in addition a solid solution of zinc in iron containing saturated 80 % of Fe; this alloy is brittle and not malleable at ordinary temperature; a 90 % iron alloy is malleable when cold. The temperature of magnetic transformation falls as zinc is added to the iron, but remains constant at 650° for the range 80 % to 22 % of Fe. H. B.

2025. *Polymorphic Transformation of Thallium, Tin, Zinc, and Nickel.* M. Werner. (Zeitschr. anorg. Chem. 83. pp. 275-321, Nov. 4, 1918.)—Polymorphism is found in the group of the magnetic metals, in the group C, Si, Ti, Zr, Sn, and sporadically in Zn and Tl. The transformation of thallium is studied by means of cooling curves and in other ways at pressures up to 8000 kg./cm.^2 . Within that range the temperature of transformation is gradually lowered, as the pressure is increased, from 228° to 220° . The heat of transformation calculated from the volume changes is 0.26 cal./gm. ; Tammann's value, from the heat of fusion, is 0.27 . Thallium wire 2 mm. in diam., 1.5 m. long, was prepared by forcing the metal through a nozzle; this wire is hard; by being heated above the transformation temperature it was changed into crystalline soft wire. The resistance of the wire was determined in an oil bath, the wire being soldered to Pt-leads from a bridge. The resistance falls sharply at the transformation temperature; that of the soft wire is 8 % smaller than that of the hard wire; the temperature coefficients of the two kinds of wire are different. As regards tin, there is a transformation under a pressure of 100 kg./cm.^2 at 168° , but it is not always distinct, nor is there any distinct discontinuity in the electric resistance at 161° , where the thermoelectric curve of a tin-nickel couple shows a break. The heat of transformation of tetragonal into rhombic tin is 0.02 cal./gm. . The thermal effect observed in zinc by Benedicks and le Chatelier at 804° is confirmed, not that at 170° (Benedicks); there is no change in the elasticity at the latter temperature either, but the electric resistance and thermoelectric force show a change. In the case of nickel the resistance and thermoelectric force curves mark breaks at 855° to 865° , when the magnetic change occurs. There is no corresponding volume-change, however, and the heat of transformation, 0.018 cal./gm. is the same for soft as for hard wires.

The paper contains some p - T diagrams and discusses the recrystallisation of hardened metals. H. B.

2026. *Hypereutectic Alloys of Iron and Carbon.* H. Hanemann. (Zeitschr. anorg. Chem. 84. pp. 1-28, Nov. 18, 1918.)—Wittorf assumed the existence of the carbides Fe_3C , Fe_4C , FeC , and possibly FeC_2 , but his estimates, especially of high temperatures by the aid of the optical pyrometer are questionable, as he melted his alloys in crucibles with the aid of the electric arc. The author fuses electrolytic iron and sugar charcoal and casts in iron chills, and concludes that the experiments prove the existence of one carbide only, cementite Fe_3C , and this only holds for the secondary, not for the primary cementite. When the bath is supersaturated with carbon, graphite rapidly crystallises, and graphite seems at all temperatures to be the stable form of carbon in the alloys. The so-called primary cementite can, at atmospheric pressure, only be obtained by excessively rapid quenching; it crystallises radially from the middle of an edge, suggesting its formation during cooling. As regards the equilibrium relations between cementite and liquid iron nothing but surmises can be offered. The paper refers in detail to the researches of Wittorf, Ruff, and others. H. B.

2027. *Specific Volumes of Nickel Steels.* P. Chevenard. (Comptes Rendus, 159, pp. 58-56, July 6, 1914.)—Since the densities of ferro-nickels at the ordinary temperatures are far from being simple functions of the composition the author has made a detailed study of the specific volumes of alloys of Fe and Ni at temperatures between -195 and 750°C . The values at the absolute zero were then calculated by the aid of Nernst's theorem. The results are plotted in the form of Specific volume—Concentration curves which at the absolute zero consist of two straight lines intersecting at the ordinate of the compound Fe_3Ni . At 0°C . the alloys between about 20 and 50 % Ni show an anomalous behaviour owing to these alloys existing in the untransformed state. This branch of the curve is characterised by a maximum at about 86 % Ni. At 750°C . the curve is made up of three branches whose points of intersection lie on the ordinates of the compounds Fe_3Ni and FeNi_2 . A study of the curves shows that the amplitude of the reversible anomaly is directly proportional to the amount of the compound Fe_3Ni contained in the alloy between the limits demanded by these two compounds. In the alloys containing less Ni, however, the amplitude of the transformation is proportional to the content of free iron.

F. C. A. H. L.

2028. *A Study of Simple Overstrain.* H. M. Howe. (Mech. Eng. 84, pp. 150-151, Aug. 14, 1914. Abstract of paper read before the Amer. Soc. for Testing Materials, Atlantic City, June-July, 1914.)—Pursuing the general conceptions that the effects of overstrain may be either isotropic or anisotropic, two forms of anisotropy may be distinguished: (1) In which the overstrain strengthens the metal against later stress in the same direction, but weakens it against stress in the opposite direction; and (2) in which the metal is strengthened in all directions but to a degree which varies with the direction of the later stress, being greatest for stresses in the direction of the overstrain itself. Though the effects of the overstrain occurring in connection with repeated reversals of stress are clearly anisotropic there is much to indicate that the effects of a single overstrain are at least partially isotropic. Annealing appears to have more effect in removing the effects of simple overstrain than those of reversing overstrain. Further experiments are needed to show the true effects of annealing on the endurance. Simple overstrain followed by rest raises the tensile strength, the elastic limit and the proportionality limit, and these effects are repetitive and cumulative. Repeated reversals, however, do not appear to raise these properties to any appreciable extent. Indeed, there is evidence to show that reversing overstrain may efface the effect of prior simple overstrain. If this is true, it then follows that any rise of the tensile strength, etc., caused by prior overstrain is fictitious as regards the endurance of stress reversals and that the effective value of the fatigue is only that existing before the prior overstrain. Therefore engineering specifications for materials which are to be subjected to reversals of stress in use should ignore such elevation of the elastic limit by providing for its removal before testing. This can be effected by a short heating to 600°C . On the other hand, the results of Bairstow's work indicate that the elevation of the proportionality limit by cold-work is fictitious as regards stresses which, although varying within wide limits, yet remain constant in sign. This is opposed to common observations, of which the author cites several examples. It may be, however, that this persistence of the effects of overstrain during repetitions of stress both with and without change of sign is only temporary. Thus with moderately overstrained material Bairstow found that permanent set arose only after some 8000 stress reversals between

—8·8 and 18·8 tons per sq. in. It may be, therefore, that the very high overstrain existing in such materials as hard-drawn wire is practically permanent and will persist through an almost indefinite number of stress-cycles. No definite conclusions can be drawn as to whether repetitive stress beyond the primitive elastic limit does or does not efface the effects of prior overstrain. The whole question as to whether the strengthening is or is not fictitious for services implying indefinite repetitions of stress requires very careful study. A hard-drawn wire is stiff in every direction, showing that there is some transverse effect of the overstrain produced by a tensile stress. From the fact that overstrain in one direction lowers the proportionality limit in the opposite direction, it has been inferred that the overstrain is monotropic in the sense that it strengthens in its own direction but weakens in the opposite direction. This, however, has not been shown conclusively. Tensile overstrain certainly lowers the compressive proportionality immediately after the overstrain. This is no proof of monotropy, because at this time it will be found that the tensile proportionality limit is also very low, in fact it may have been reduced to zero. On heating, or even at the ordinary temperature, the lowered limit rises very rapidly with the time, and the author knows of no evidence to show that this is not equally true of the proportionality limit in compression.

F. C. A. H. L.

2029. Local Prevention of Case-hardening and Diffusion in Solids. L. Guillet and V. Bernard. (Rev. de Métallurgie, 11. pp. 752-765, July, 1914.)—Three methods are in general use for the local prevention of case-hardening. (1) The part required soft is coated with refractory clay or cement. This method is never entirely successful on account of the difficulty of obtaining a material which possesses sufficient adhesive properties under the conditions and which is impermeable to the cementing gases at high temperatures. (2) The article is left too big in the parts required soft by an amount which is at least equal to the depth of the case, and then excess of material is machined away prior to quenching. In pieces of simple section this can also be done by covering the part with steel tubing prior to carbonising. After hardening the tube can be cracked away with a hammer. (3) A thin coating of metal is deposited on the part to be protected. To be effective the metal chosen should be solid at the temperature of carbonising, should be impermeable to the carbonising agencies under the conditions of working, should be readily obtained commercially, and should be capable of removal after the operations are completed. Only copper and nickel fulfil these conditions, and they may be deposited either electrolytically or by the Schoop process. Electro-deposited Ni was found to be permeable to CO at high temperatures with the result that the only effect was to produce a slight retarding of the rate of carbonisation. Simple immersion in solutions of copper salts gave unreliable results on account of the variations of the thickness and adherence of the layer. A thickness of 0·02 to 0·08 mm. of electro-deposited copper was found to give absolute protection at 1000° C. Similar results were obtained with deposits of copper obtained by the Schoop process. It appears therefore that copper deposition provides the practical solution, the choice as to whether the deposit is produced by the electrolytic or the Schoop process depending upon circumstances to a very large extent.

The authors have also made a study of the diffusion of metals into each other in the solid state. The phenomenon appears to be a very general one, and, providing that the contact is sufficiently good, can always occur when the two metals form solid solutions with each other. A knowledge of the con-

stitution of the alloys gives, therefore, the information as to whether two metals will, under certain temperature conditions, diffuse into each other or not.

F. C. A. H. L.

2030. *Granular Pearlite and Its Importance in the Heat-treatment of Steel.* Hanemann and Morawe. (Stahl u. Eisen, 88. pp. 1850-1855, 1918. Rev. de Métallurgie, 11. pp. 451-458, July, 1914.)—The origin of lamellar pearlite is regarded as being due to the solid solution becoming supersaturated with regard to one of the constituents (ferrite or cementite) during cooling. Corresponding to the position of each grain, a layer of cementite (in hypereutectoid steels) then separates and the solution becomes supersaturated with respect to ferrite which then forms another layer and again renders the solution supersaturated with cementite. The cycle of operations is repeated until the mass consists of a series of grains, in each of which the lamellæ are approximately parallel. Various writers have, however, described steels in which the cementite exists in the form of globules surrounded by the ferrite. This form has been called "granular pearlite" by the authors who have investigated the conditions under which it may be formed and the variation in the mechanical properties of the steel brought about by its presence. It is formed most easily in steels containing an excess of either ferrite or cementite over the eutectoid composition, and, in fact, in steels containing over 1.8 % carbon it forms the usual structure. Granular pearlite may be formed by cooling slowly through the A_{r1} interval, by alternate heatings just above and below A_{r1} , by tempering a quenched steel at between 650° and 700° C., or by prolonged annealing of lamellar pearlite at temperatures slightly below A_{c1} . The conversion of the pearlite into the granular variety lowers the elastic limit and the tensile strength and increases the ductility. Bending tests show that the flexibility is also increased, a striking result being the extreme flexibility of a steel containing 1.56 % of carbon. The lamellar structure can easily be restored by heating at 800° C., followed by slow cooling, when the original properties are regenerated. The authors propose to call steels in which the pearlite has been converted into the granular condition, as "soft-annealed." Granular pearlite occurs in steels which have been cold-drawn or cold-rolled and also in damascened steel.

F. C. A. H. L.

2031. *The Solidification of Metals.* C. H. Desch. (Inst. of Metals, Journ. 11. pp. 57-106, 1914. First Report of Beilby Prize Committee. Engineering, 97. pp. 437-440, March 27, and pp. 471-474, April 8, 1914.)—Summarises the present extent of our knowledge on a part of this subject.

2032. *Dielectric Constant and Solvent Power of a Liquid.* W. E. S. Turner and C. C. Bissett. (Chem. Soc., Journ. 105. pp. 947-952, April, 1914.)—Walden has found a relationship, $\epsilon\mu^{-1/2} = \text{const.}$, between the dielectric constant of the solvent and the "molecular solubility" μ of the salt tetraethylammonium iodide. Experimental tests have shown that no equality exists in the value of this expression for eight substituted ammonium salts in water and in chloroform, nor for lithium chloride in water and four alcohols, nor for tetrapropylammonium iodide in 15 solvents; nor is there any parallelism between the dielectric constant of the solvent and its solvent power for non-electrolytes such as *p*-nitrobenzyl chloride, trimethylamine and the common gases. On the whole, the dielectric constant of the solvent appears to exert an influence only when the solute is an electrolyte, and even then it is not the controlling factor in producing solution.

T. M. L.

2033. *Fluctuations of Concentration in a Colloidal Emulsion.* R. Costantin. (Comptes Rendus, 158. pp. 1841-1848, May 11, 1914.)—The simple formula used by Svedberg does not represent the distribution of particles in a concentrated emulsion, but the formula of Smoluchowski relating the variations of concentration to the compressibility gives a satisfactory agreement.

T. M. L.

2034. *Osmotic Data in Relation to Progressive Hydration.* W. R. Bousfield. (Roy. Soc., Proc. Ser. A. 90. pp. 544-548, Aug. 1, 1914.)—Starting with Callendar's conception of osmotic pressure [Abstract No. 1720 (1908)], in which a "vapour-sieve piston" is used to deduce a relation between osmotic pressure and vapour pressure, the author deduces the relationship $\delta p/p = i/(h - n)$, where p is the vapour pressure, h the total water, n the combined water, and i the van't Hoff factor.

T. M. L.

2035. *Influence of Temperature on the Density and Conductivity of Aqueous Salt Solutions.* II. H. Clausen. (Ann. d. Physik, 44. 7. pp. 1067-1076, July 17, 1914.)—Data are given for the densities of solutions of RbNO_3 , RbCl , RbBr , RbI , Rb_2SO_4 , CsCl at 6° , 18° , 80°C . These data are used to calculate the constants in the equation $\Delta_s = \Delta_s i + B_s(1 - i)$. [Compare Abstract No. 959 (1912).]

T. M. L.

2036. *Extension of the Dilution Law to Concentrated Solutions.* J. Kendall. (Amer. Chem. Soc., Journ. 86. pp. 1069-1088, June, 1914.)—Ostwald's "Dilution Law" gives $c_i^2/c_u = K$ where c_i is the concentration of the ionised and c_u the concentration of the un-ionised part of the salt. If it be assumed that ionisation is brought about by the mass-action of the solvent, this equation becomes $c_i^2/c_u = K \cdot c_s$. For dilute solutions c_s is constant, but it varies at higher concentrations. If a correction be made for this and for the changing viscosity of the liquid, the dilution law can be extended to $N/2$ in the case of the fatty acids and ammonia, which otherwise show marked deviations at $N/10$.

T. M. L.

2037. *Fluidity as a Function of Volume, Temperature, and Pressure.* E. C. Bingham. (Amer. Chem. Soc., Journ. 86. pp. 1898-1406, July, 1914.)—Fluidity is proportional to the "free volume" of Batschinski, in pure liquids and mixtures, and in suspensions of solids in liquids, i.e. $v = w + c\phi$, or $\phi = 1/c(v - w)$; where v is the volume, w is the limiting volume toward which the volume approaches as the fluidity approaches zero, and $v - w$ is the free volume. An equation resembling that of van der Waals may be used, therefore, to reproduce the fluidity data as a function of the temperature and pressure. Such an equation breaks down when applied to gases, the fluidity of a gas being invariably smaller than would be expected from the modified van der Waals' equation. Viscous resistance in gases originates largely in the diffusion of the moving material, the energy of which is converted by repeated collisions into disordered motion. This motion is called "diffusional viscosity." In viscous liquids the resistance to flow caused by diffusion is negligible. The resistance is due mainly to the collisions of molecules of one layer with those of an adjacent layer moving at a slightly lower velocity. This transfer of momentum without a transfer of matter is called "collisional viscosity." The viscosity of a gas or liquid is the sum of the diffusional and collisional viscosities. We thus obtain an approximate formula $\phi = (v - w)/[A + BT(v - w)]$ which can be used to reproduce the observed fluidities of CO_2 with considerable fidelity. The apparent

viscosity of a gas as it becomes rarefied, decreases rapidly, in accord with the theory that slipping does not occur even in rarefied gases. In gases at ordinary temperatures and pressures, the fluidity decreases as the temperature is raised, but is nearly independent of the pressure, indicating that diffusional viscosity is of preponderating importance. At very low temperatures, however, the fluidity is inversely proportional to the pressure. At very high temperatures the fluidity may increase with the pressure. The fluidity of practically all liquids increases with rising temperature and decreased pressure, probably on account of the decreased number of collisions. Sulphur and water are exceptional on account of association. In nearly all liquids an increase in the molecular weight causes an increase in the temperature required to produce a given fluidity; in homologous series this increase is proportional to the increase in molecular weight. Formic and acetic acids are exceptions on account of their association.

T. M. L.

2038. *Ionisation and the Law of Mass Action. III. Utilisation of the Osmotic Data and a New Dilution Law.* W. R. Bousfield. (Chem. Soc., Journ. 105. pp. 1809-1828, July, 1914.)—The two quantities, α = coefficient of ionisation, n = combined water, appear in such a way that the three equations furnished by the osmotic data are no better than one; neither α nor n can therefore be determined except when the hydration h is so great that n can be neglected. Under these conditions all the mass-action equations (except Ostwald's) become identical [see Part I, Abstract No. 1105 (1918)]. The equation now proposed to express the dilution law is $\alpha^2/1 - \alpha = K(h - n)^{1/2}$. Unlike former equations it contains a term n which must be found experimentally, but it has the advantage that it may be deduced from the law of mass-action, by assuming that the final stage in the process of ionisation is the attack of a single molecule of dihydrol, H_2O_2 , on two molecules of the solute. Neither α nor n can be deduced from the conductivity, as the ionic mobilities are quite unknown except in dilute solutions, but data may be obtained from osmotic measurements, and especially from the vapour pressures. In the special case of lithium chloride, the evidence indicates that $n = 88\alpha - 14$, so that at infinite dilution $n = 24$, where a determination by another method has given $n = 21$. In a saturated solution at 18° there are only 8 molecules of water, and the combined water n is probably 1.4, whence $\alpha = 0.4$, i.e. there are 0.6 mols. $LiCl$, H_2O (not ionised) and 0.4 mols. $LiCl$, $2H_2O$ (ionised).

T. M. L.

2039. *Variation of Electric Potential across a Semipermeable Membrane.* F. G. Donnan and G. M. Green. (Roy. Soc., Proc. Ser. A. 90. pp. 450-455, July 20, 1914.)—Experiments were made to test whether the p.d. between two solutions of an electrolyte, separated by a membrane impermeable to it but permeable to the solvent, agreed with those calculated from a formula already given. Potassium ferrocyanide was used with copper ferrocyanide membranes. In all cases in which one solution was normal, large deviations (28 to 29%) were found, probably because the transport numbers and degree of ionisation are so uncertain. Using solutions from N/10 downwards, the deviations ranged from 2% for N/10 against N/20 to 14% for N/10 against N/200; this increasing error seems to be due to growing errors in the calculation of the "diffusion potential" when no membrane is present, the p.d. introduced by the membrane being correctly represented by the formula $\pi_2 - \pi_1 = RT/F \cdot \log (a_1/a_2)$, where a_1 and a_2 are the "activities" of the potassium ion in the two solutions.

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T. M. L.

2040. *Diffusion and Membrane Potentials.* E. B. R. Prideaux. (Faraday Soc., Trans. 10. pp. 160-165; Discussion, pp. 165-166, Aug., 1914.)—The author has measured the diffusion e.m.f. of the combination: $\text{Hg}, \text{HgCl}, \text{N-KCl} \mid \text{NaB}(\text{C}_1) \mid \text{NaB}(\text{C}_2) \mid \text{N-KCl}, \text{HgCl}, \text{Hg}$, where $\text{NaB}(\text{C}_1)$, and $\text{NaB}(\text{C}_2)$ represent solutions of sodium benzoate of the concentrations C_1 and C_2 . In one set of experiments the solutions were connected by means of a siphon tube, whereas in the other they were separated by a parchment membrane, which was held in position by a suitable arrangement. The e.m.f.'s given by the ordinary diffusion potential were found to be represented by the straight line: E (millivolts) $= 1 + 18.5 \log (a_1 \text{C}_1 / a_2 \text{C}_2)$, where a_1 and a_2 represent the dissociation of sodium benzoate in the respective solutions. Since the diffusion potential is also given by the equation $E = 0.058(1 - 2n_A) \log (a_1 \text{C}_1 / a_2 \text{C}_2)$, the transport number of the anion (n_A) can be calculated, and is found to be 0.888, in good agreement with the value calculated from the ionic mobilities, namely, 0.888. When the two solutions were separated by a parchment membrane, the diffusion potential was represented by the straight line: $E = 4.58 + 24.8 \log (a_1 \text{C}_1 / a_2 \text{C}_2)$, from which it follows that $n_A = 0.286$. The transport number of the anion in the membrane is thus less than three-quarters of its value in the free solution. It is remarkable that the straight line does not, as in the case of diffusion potentials, pass almost through the origin, but intercepts an ordinate of 4.5 millivolts. The author is unable to suggest an explanation of this. T. S. P.

2041. *Electrometallurgy of Aluminium.* P. P. Fedotieff and W. Iljinsky. (Zeitschr. anorg. Chem. 80. pp. 118-154, 1918.)—The authors study the electrolysis of aluminium in fused cryolite as technically applied with special regard to the system $\text{AlF}_3\text{--NaF}$. The statements as to the melting-point of cryolite are contradictory because the cryolite is impure and contains in particular silica, in appearance like the cryolite. Aluminium fluoride cannot be deprived of its water by heating, because hydrolysis into HF and Al_2O_3 sets in; but the salt can be sublimed yielding large crystals when not cooled too quickly; the anhydrous salt is not attacked by concentrated sulphuric acid. The pure cryolite $8\text{NaF} \cdot \text{AlF}_3$ melts at 1000°C .; there is also a compound $5\text{NaF} \cdot \text{AlF}_3$, the (mineral chiolite) which does not melt, but is transformed into cryolite and a liquid at 725° ; at 565° monoclinic cryolite passes into regular cryolite, the eutectic points at 685° and 890° correspond to 14 and 46.4 mols. per cent. of AlF_3 . Cryolite and alumina form solid solutions, but alumina is more soluble in the eutectic $\text{NaF--Na}_3\text{AlF}_6$ than in cryolite, with the curves passing through a minimum; alumina is not soluble in NaF , and its solubility in the cryolite is diminished by the addition of AlF_3 . The continued reduction of Al from the bath requires a p.d. of 2.1 or 2.2 volts. But gas is generated at 1.8 volts already, and the formation of metallic fog (emulsification) follows. Owing to this emulsification and also to the formation of the carbide Al_4C_3 the yield of Al does not exceed 70 %. The carbide is formed independent of the current in the fused mass at the anode when the temperature is between 1000° and 1100° . When the bath is too rich in alumina near the anode, the potential rises, and sparks may be observed; the bath should be stirred, and rotating anodes might answer. The destruction of the anodes is accelerated by the addition of NaF to the bath. The melting-point of the salts can be lowered by using chiolite instead of cryolite and keeping the alumina-content down to 7.5 %. The melting-point is also lowered by the addition of CaF_2 to the bath; but the bath is then denser and does not dissolve alumina so readily; a eutectic of the two fluorides, Ca and Al , is formed at 815 to 820° and contains 87.5 mols. per cent. of AlF_3 . H. B.



